

134

A New and Easy GUIDE to
The USE of the GLOBES;
AND THE
Rudiments of Geography.

WHEREIN

The Knowledge of the HEAVENS and EARTH is made easy to the meanest Capacity: First, by giving a concise Account of the four Quarters of the World, with the Distance and Situation of the principal Islands and inland Places; and Secondly, by the Solution of upwards of Seventy useful Problems, in *Geography, Astronomy, Navigation, and Dialling.*

In which are inserted

FOUR useful TABLES.

- | | |
|---|--|
| I. Shews the Latitude of the principal Places, and their Longitude from the Meridian of London. | III. Shews where every Climate ends, with the length of the longest Day at the End of each. |
| II. Shews the Number of Miles contained in a Degree of Longitude, at every Degree of Latitude. | IV. Shews the Right Ascension, Declination, Latitude, and Longitude of the most eminent fixed Stars. |

To the whole are subjoined,

I. AN APPENDIX;

Containing a short Account of the SOLAR SYSTEM, and of the COMETS and FIXED STARS:

II. A SUPPLEMENT;

Exhibiting a brief View of the Figure and Magnitude of the Earth, of the Nature of the Atmosphere, of the Theory of the Tides, and a concise System of Chronology.

By DANIEL FENNING,

Author of the School-Master's Useful Companion, or Scholar's best Instructor; the Royal English Dictionary, published by the King's Authority; the British Youth's Instructor, or, a New and Easy Guide to Practical Arithmetic; the Young Man's Universal Companion; and the Young Man's Book of Knowledge.

The SIXTH EDITION.

CORRECTED AND IMPROVED, BY

JOSEPH MOON, MATHEMATICIAN, SALISBURY.

Recommended by the Rev. J. WARNEFORD, M. A. and several eminent MATHEMATICIANS.

In this Edition is inserted a VIEW of the COPERNICAN or TRUE SYSTEM of the UNIVERSE, and the COELESTIAL GLOBE, neatly engraved.

L O N D O N:

PRINTED FOR S. CROWDER, IN PATERNOSTER-ROW. 1792.

*Recommended by several of the most eminent Schoolmasters and
Arithmeticians in the Kingdom as the best Book of the kind extant.*

T H E
B R I T I S H Y O U T H ' s
I N S T R U C T O R :
Or, A NEW and EASY GUIDE to
P R A C T I C A L A R I T H M E T I C .

WHEREIN THE
Rudiments of common ARITHMETIC, VULGAR
and DECIMAL FRACTIONS, the Extraction and
Use of the SQUARE and CUBE ROOTS, &c.

Are so easily treated of, and so plainly Demonstrated,
That any Person may, of himself, (in a short Time) become
acquainted with every Thing necessary to the
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from another, may state and balance their own Accounts cor-
rectly, and have a clear View of all their Transactions.

The whole designed for such as have hitherto neglected, or have not
had an opportunity of becoming acquainted with Figures; and
attempted in natural and familiar Dialogues, in order to render
the Work more easy and diverting, as well as useful to Learners.

By DANIEL FENNING,

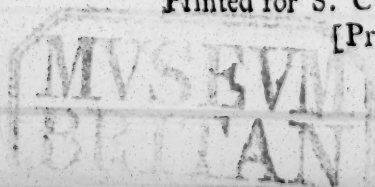
Author of the Young ALGEBRAIST'S COMPANION; Description
and Use of the GLOBES (both in Dialogues); the Universal
SPELLING-BOOK; Royal English DICTIONARY; Young
Man's BOOK of KNOWLEDGE; a new English GRAMMAR;
a new; Treatise on MENSURATION; and the Young Man's
UNIVERSAL COMPANION.

The TWELFTH EDITION, revised, corrected, and improved,
By W. BURBIDGE, SCHOOLMASTER, in *Salisbury*.

L O N D O N :

Printed for S. CROWDER, PATER-NOSTER-ROW.

[Price bound Three Shillings.]



DEDICATION.

To all public Tutors and Lovers of Mathematical Learning, especially those that I have had the Honour to instruct.

THE Study of the Use of the Globes is now become very common among Gentlemen, in comparison of what it was some few years ago. There are Numbers that cannot bear the Thought of going through a tedious and regular Course of Geometry, Trigonometry, Algebra, &c. yet find a great Pleasure in learning upon the Globes; and this I imagine is because the Knowledge of them is so readily attained. Nothing is easier than practical Geography, commonly called The Use of the Globes, because no other Branch of Learning is previously necessary. He that can read well, may arrive at the Knowledge of them almost as soon as another that is well acquainted with Figures.

Some of you may think it a Presumption in me to publish a Book upon the

Use of the Globes, when so many are already extant upon the same Subject, and especially as Dr. Harris's is so much used: But many of you may remember I have been obliged to explain him to you; and you have owned he is not so clear in many of the Problems as could be wished. Besides, his is a general Treatise of the Rudiments of Astronomy, mixt with the Use of the Globes; but this little Tract, except in the Appendix, treats of Nothing of that Sort, but goes through a Series of Problems (as you will see more particularly in the Preface) Step by Step; and as every Problem has an Answer, you cannot be at a Loss to know when you are right.

As I have endeavoured to render it both easy and useful in all public Academies, &c. as well as to private Gentlemen, you will, no Doubt, excuse some few Errors; and in giving it a kind Reception you will do me great Honour, and very much oblige,

Your humble Servant,

D. FENNING.

P R E F A C E.

KIND READER,

I Here present you with a small Treatise of Geography, and The Use of the Globes.

The Geographical Part, you may naturally suppose, I borrowed from different Authors, who, no Doubt, were obliged in the same Manner to borrow their Accounts from previous Publications: And this is always allowable in History, though not in every Part of Learning.

Besides, many Hundreds may happen to light on one Book, who may never see another on the same Subject; therefore a Number of Books can never fail of being serviceable to the Public; and if every Author makes but an Improvement in what he takes in Hand, he does well, and the Reader is in some Measure obliged to him. It may be asked what Improvements can be made here, since there are so many large Volumes upon the Subject, and these written by the most eminent Authors? I answer, that as my Knowledge is not sufficient, so my Intention never could be to give

a better Account of Things than they have done. But the Point in Hand is, whether I have not drawn the Work into a narrower Compass, so as not to burthen the Memory, and yet, at the same Time, made it so distinct as to convey a clear and satisfactory Idea of what is both necessary and useful to every common Reader. If I have in any Respect done this, I have done as much in the Geographical Part as I intended, and more; for my Design at first was only to treat of the Description and Use of the Globes; therefore I hope, if any Errors have crept into the first Part, they will be pardoned. For

Some Authors differ from others. Thus Gordon says, that the Metropolis of Maryland is Baltimore, in Honour of Lord Baltimore; but Taylor and Dampier say Annapolis Royal is the Capital.—Which of these is right I cannot determine; only this I say, that Gordon seems to be right according to History, and Taylor according to Custom; because Annapolis-Royal is the chief Place of Traffic and Business. But I leave this to better Judges, and will now give some Account of the Work in general.

Dialogue I. II. III. and IV. Contain a
short

short and easy Account of the Situation of the principal Places in the known World, with their Distance from London, in an Arch of a great Circle.

Dial. V. and VI. Contain a general Description of the Globes, with the Nature and Property of the Sphere, and the different situation of the Inhabitants of the World in respect of each other.

Dial. VII. An Explanation of the most useful Terms in Geography; to which are annexed, Four useful Tables.

1. Shews the Latitude of the principal Places, and their Longitude from the Meridian of London.

2. Shews the Number of Miles contained in a Degree of Longitude, at every Degree of Latitude.

3. Shews where every Climate ends, with the length of the longest Day at the End of each.

4. Shews the right Ascension, Declination, Latitude, Longitude, &c. of the most remarkable fixed Stars, taken from Senex's Globes.

Dial. VIII. Contains 77 Problems performed by the Globes, many of which are very useful in shewing the Nature of Spherical Triangles, and are applied to Navigation, Dialling,

Dialling, &c. and I have not only given you the Rule to work them by, but have given you the Answers to the Problems, that you may know when you are right. If indeed your Answer be not exactly the same with mine in Respect to Minutes, never mind that; for I have taken the nearest Quarter of a Degree for this Part of the Answer: Thus, if it were 12 Minutes I call it 15 or $\frac{1}{4}$ of a Degree; I have done the same when it is 20 Minutes; but if it be near $\frac{1}{2}$ a Degree on the Quadrant, I call it 30 Minutes; and this I have done on Purpose to avoid puzzling the Learner, because we cannot guess to a Minute or two on the Quadrant, and Globes will often differ for want of good Appendants.

As for the distance of Places from London, I have taken it from no Book or Person; and though I agree with Echard and several others, in Respect of Degrees, yet I differ from them in my Answer in Miles, most of them allowing but 60 Miles or Minutes to a Degree, whereas I have counted $69\frac{1}{2}$ to a Degree. If you cannot multiply the Degrees by $69\frac{1}{2}$, then multiply by 70, and take $\frac{1}{2}$ the Number of Degrees out of that Product; this is the same as multiplying by $69\frac{1}{2}$.

In fine, I have endeavoured to render this Book as useful as I could, and I am persuaded

ed any Body may (of himself) learn the Use of the Globes by it, if he will but take the Trouble to learn the Signs and Terms previous to such an Undertaking.

Arts and Sciences are not to be learned by mere Reading only; there must be some Practice, or else the bare Reading will never make a complete Artist; and if so, how can it be expected that he should become a Proficient that never reads at all?

It is not having a Thousand Volumes in your Library, that will convince the World you understand them; for without a little Pains, you will never be a Jot the wiser in the practical Part of the Mathematical Studies.

But as for the Use of the Globes, it is so plain and so easy, that most Persons esteem it a Pleasure, rather than a Labour; and as the Knowledge of them is very useful as well as entertaining, I would recommend it to young Gentlemen in general, as they may learn the Use of them without Pains, and, in short, without Loss of Time.

To render the Work still more perfect, I have added an Appendix, containing a short Account of the Solar System and of the Comets and fixed Stars.

*I am, kind Reader,
Your humble Servant, and Well-wisher,*
D. FENNING.

ADVERTISEMENT

TO THE

SIXTH EDITION.

THE Editor of the present edition having made use of this book in his School many years, (it being the best practical treatise of the kind extant) became thereby a better judge of what was wanting to render it more complete. And, by correcting errors, supplying deficiencies, illustrating obscurities, expunging what was either obsolete, superfluous, or unscientific, and substituting recent and interesting matter in its stead, he hopes he has so far improved this impression as greatly to facilitate the progress of the learner.

THE additional Tables, page 79 and 80, it is presumed, are more correct than any others of the kind extant.

TABLE IV, of the Stars, being now corrected, both in Right Ascension and Longitude, to the beginning of the year 1792; if those who use old Globes should not find the Stars exactly in the situation there mentioned, the fault is to be attributed to the Globes and not to the Table.

IN fine, if an exact comparison be made, by a candid and judicious person, between this and the last edition, the editor has no doubt but the superiority in favour of the present will be obvious.

 The Notes at the bottom of pages 56, 59, 70, 83, 87, 101, 115, 124, 142, and Prob. and Note 118 and 119, are by the Editor,

JOSEPH MOON.

TO THE
P U B L I C.

WE whose names are hereunto subscribed, having perused this epitome of Geography, are of opinion, that it is very well adapted to the capacity of all such as, without much previous reading, would speedily acquire a true notion of the situation of the principal places in the known world. And for the variety of Problems it contains, and which are so clearly set forth, and so plainly demonstrated, we beg leave to recommend it to every learner, as the most useful book extant. Witness our hands,

Rev. J. Warneford, of *Darking, Surry.*

George Coles, *Surveyor.*

Henry Deacon, *Accomptant.*

Edward Griffiths, *Surveyor and Accomptant.*

Anthony Gilbert, *Surveyor.*

Abraham De Lire, *Philo Math.*

John Quant, *Teacher of the Mathematics.*

William Simson, *Philo Math.*

John Smythe, *Accomptant.*

James Thurston, *Ditto.*

To the PUBLISHER of MR. FENNING'S NEW USE
of the GLOBES.

Darking, May 9, 1785.

S I R,

THE Alterations you propose introducing in a New Edition of Fenning on the Globes, will be an additional Recommendation of that useful little Treatise, to

Your obedient Servant,
J. WARNEFORD.

TO THE
R E C O M M E N D E R S.

GENTLEMEN,
I Return you hearty thanks for your kindness in honouring me with your names to this small Treatise. Your assistance in discovering any errors that I have omitted correcting, will still further oblige,

GENTLEMEN,
Your very humble Servant,
 Daniel Fenning

DIRECTIONS *to the Bookbinder for placing the*
 MAPS and CUTS.

Map of the World	-	-	fronting the Title-page	
— Europe	-	-	-	Page 7
— British Empire	-	-	-	16
— Asia	-	-	-	20
— Africa	-	-	-	24
— North America	-	-	-	31
— South America	-	-	-	37
Terrestrial Globe	-	-	-	47
Cælestial Globe and Sphere	-	-	-	71
Copernican System	-	-	-	163



A NEW and EASY
G U I D E
TO THE
USE of the G L O B E S.

DIALOGUE I.

*Between PHILO, a Tutor, and TYRO, a Pupil,
concerning GEOGRAPHY in general.*

S E C T. I.

Tyro.



YOU have already been so kind, dear *Philo*, as to instruct me in the principles of common arithmetic, and the rudiments of algebra, and you promised to instruct me also in the use of the globes: if therefore it be agreeable to you, I shall be very glad to begin immediately.

Philo. With all my heart; it pleases me much to see you delight in any thing of this sort, rather than spend your time in idleness, which is the parent of mischief; I am therefore as ready to teach you as you are willing to be
B taught:

taught: but I think it will not be amiss to give you first a little notion of geography, as it will not only qualify you the better for this undertaking, but will be a great help to you for the more ready understanding whatever you read.

Tyro. I thank you, sir; for indeed I have very little notion of, and scarce know what you mean by geography.

Philo. Geography is a Science which explains the properties of the earth, both in respect to land and water; for of these two parts the terraqueous globe is composed.

Tyro. You say the earth is a globe: I should be glad to be informed how it is possible to know of what figure the earth really is.

Philo. The roundness of the earth may be proved by a variety of arguments: 1. When we are on board a ship at sea, we may be out of sight of land, when the land is near enough to be visible, if it were not hid from our eye by the convexity of the water. In this case, the tops of hills, cliffs, steeples, towers, &c. first appear to our view, next the buildings, and last of all the shore; which can proceed from nothing else but the roundness of the earth, whereby the lower objects are longer hid from the sight, than those which are higher. 2. The higher the eye is, the farther will the view be extended: it is very common for seamen, on the top of the mast, to discover land, or ships, at a greater distance than those can do who stand upon the deck; the object being hid from the latter by the convexity of the water. 3. When we stand upon the

the shore, the highest part of a ship is visible at the greatest distance; if a ship be going from us out to sea, we shall continue to see the mast, after the hull or body of the ship disappears, and the top of the mast will be seen longest. But if the surface of the sea were a flat, every part of an object would be equally visible; and not the highest, but the largest part of an object, would be visible at the greatest distance, so that we should be able to see the hull of a ship farther off than the mast: But this is contrary to experience; consequently the earth is round. 4. The convexity of the water may be seen in calm weather, and where the fluid is unruffled by the agitation of the stream, provided it be a mile or two in a straight line, for a little boat upon the water may be seen by a person whose eye is a small height above the water; but if he stoops down and lays his eye near the surface, he will find that the boat is covered by the convexity of the water. 5. Several navigators have sailed quite round the earth; not in an exact circle, the winding of the shores preventing them from sailing on a direct course; but by sailing continually to the westward, they have reached the place from whence they at first departed. This was performed by Magellan, Cavendish, Sir Francis Drake, Lord Anson, Bougainville, Commodore Byron, the Captains Carteret, Wallis, Cook, and others. 6. All the appearances of the heavens, both at land and sea, are the same as they would be were the earth a globe, which proves that it really is such. And, lastly,

B 2

eclipses

eclipses of the moon, which are caused by the shadow of the earth falling on that planet, demonstrate that the earth is of a globular figure; for this shadow is always circular, whatever situation the earth may be in at that time: Now a body must be globular which always casts a circular shadow. Nor are the little unevennesses on the earth's surface, arising from hills and vallies, any material objection to its being considered as a round body; because the highest mountains bear a less proportion to the bulk of the earth, than the little risings on the coat of an orange bear to that fruit; or a grain of sand to an artificial globe, of nine inches diameter; and accordingly, we find that the mountains and vallies on the surface of the earth, cause no irregularities in the shadow, during a lunar eclipse; the circumference thereof being even and regular, and appearing as if cast by a body truly globular.

Tyro. I am convinced, from the reasons you have given, that the earth is round; and should be glad to know the methods that have been taken to measure it, or find the dimensions of this globe.

Philo. The methods made use of to measure the earth are very plain and easy to be understood. But it will be necessary to observe, that every great circle, and consequently the circumference of the earth, is divided into 360 equal parts, called degrees, and every degree into 60 equal parts, called minutes, &c.

Tyro.

Tyro. This I have already learned in common arithmetic; but should be glad to know why every circle contains neither more nor less than 360 degrees.

Philo. It was necessary to give the preference to some number; and probably that of 360 was fixed upon for this reason, that it admits of several convenient divisions as well by the figure 2 as 3. Thus the half is 180, the quarter 90, and the half quarter 45. Also the third of 360 is 120, the third of which again is 40. Few other numbers can boast of this advantage, especially as every number in both the above divisions is also further divisible by five.

Tyro. You have sufficiently satisfied me in this particular; and now I think I am capable of understanding the method made use of in measuring the earth.

Philo. As every circle is divided into 360 degrees, if at two places situated North and South of each other, the altitude of the sun be taken on the same day at noon, and the sun be found to be one degree nearer to the zenith at one place than at the other, those two places are one degree asunder. Now if the distance between these two places be measured by a chain or otherwise, we shall know the length of a degree, and consequently of any part of a degree, in English measure. This has been done by several geographers, particularly by our countryman Mr. Richard Norwood, who, in the year 1635, observed the difference of latitude, and measured the distance between London and York.

By which it appeared that 367,200 English feet, or 69 miles and a half, and 14 poles, make a degree. Hence the whole circumference of the globe will be 25,020, and its diameter 7,970 English miles, reckoning 69 and a half to a degree. If the odd poles be taken into the account, the circumference will then be 25,035 miles and 240 poles.

The map of the world, prefixed to this work, will give you a much better idea of the world itself, than the best verbal description. It represents the artificial globe taken out of its horizon, squeezed flat, cut through, and the two hemispheres placed close to each other.

Tyro. Into how many parts is the earth divided?

Philo. Into 4 parts, or quarters; viz. 1. Europe, 2. Asia, 3. Africa, and 4. America.

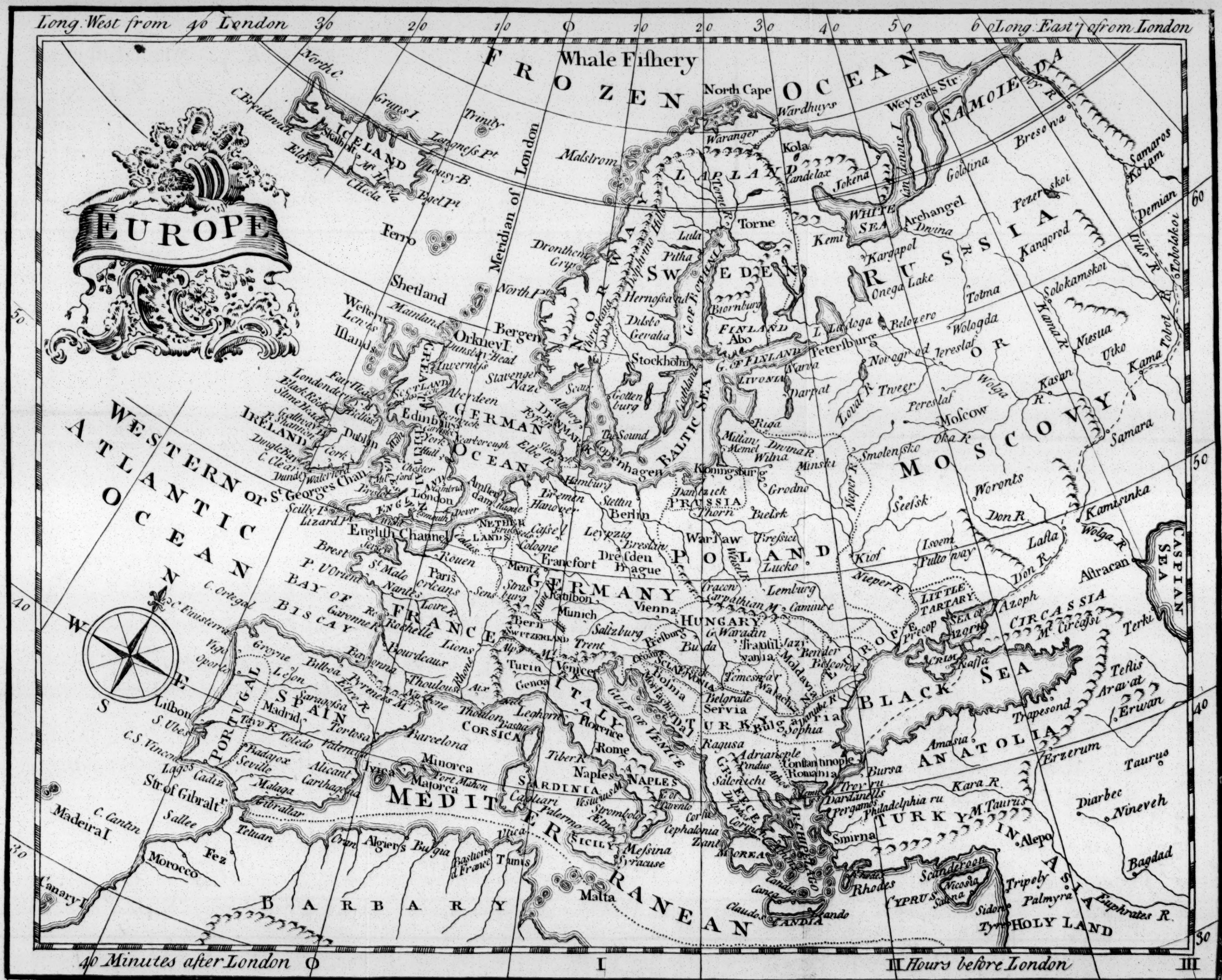
Tyro. What are the other nominal parts of the earth; or how is it yet further divided in relation to land and water?

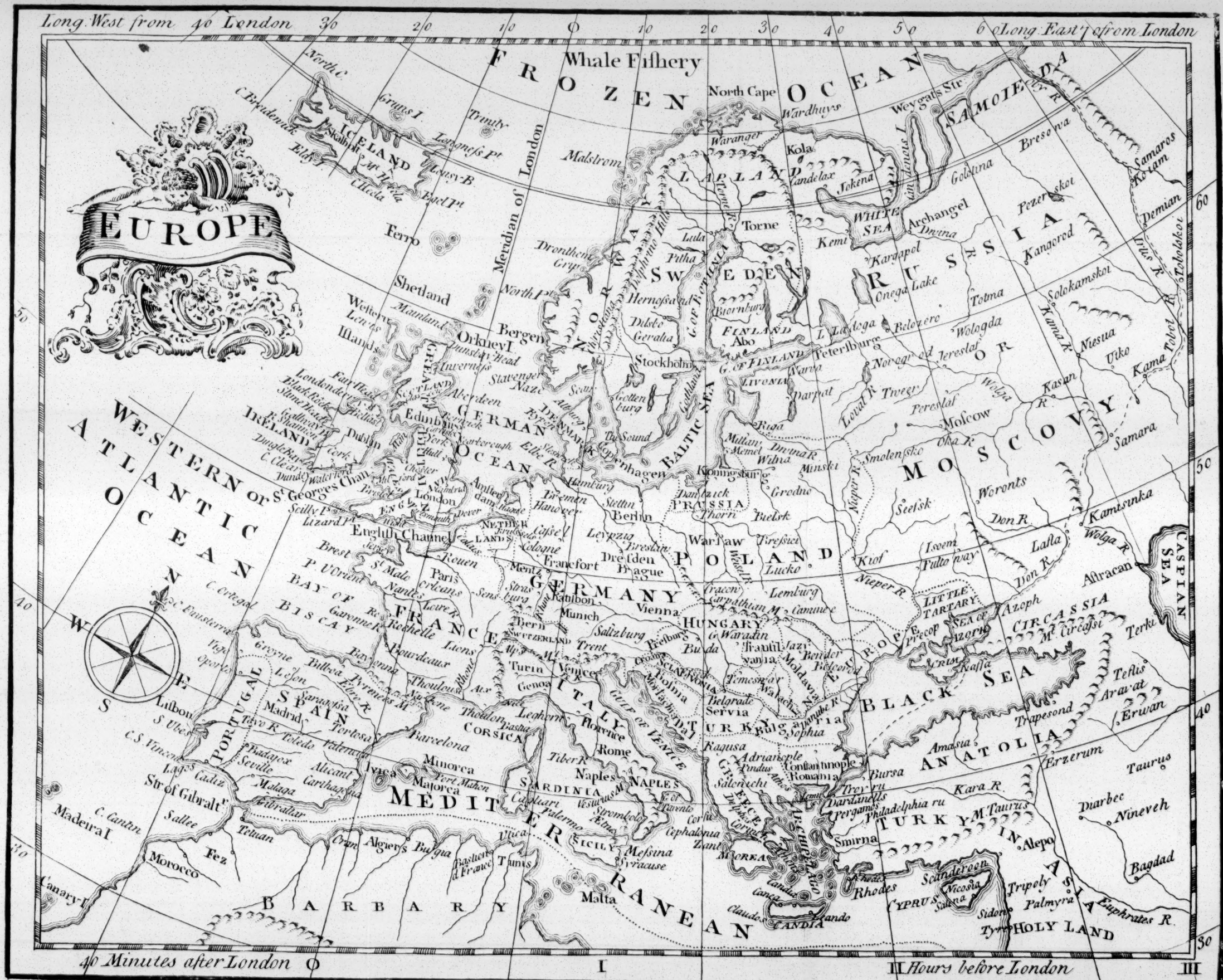
Philo. It is divided into 10 different parts; 5 belonging to land; viz. 1. A continent. 2. An island. 3. A promontory or cape. 4. A peninsula. And, 5. An isthmus. The other 5 belong to water; viz. 1. An ocean. 2. A lake. 3. A bay. 4. A gulf. And, 5. A strait. These answer to each other, as more plainly appears by the following description.

LAND.

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J. Gibson Sculp.

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LAND.

1. A continent is a large tract, or vast extent of main land, not separated by any ocean. Thus Europe, Asia, Africa, &c. are continents.

2. An island is a tract of land surrounded with Water; as Great Britain, Ireland, Jamaica, Madagascar, &c.

3. A promontory, or cape, is a portion of land running far into the sea; as Cape Verde, Cape of Good Hope, &c.

4. A peninsula is a part or portion of the earth almost surrounded with water, save only a part or narrow neck of land which joins or unites it to a continent; as Jutland, the Morea, Crim Tartary, &c.

5. An isthmus is a narrow part of land, by which a peninsula is joined to a continent or main land; as the isthmus of Panama, which joins North and South America together; the isthmus of Corinth, &c. &c.

WATER.

1. An ocean (or sea) is a large extent or collection of waters, not divided by land; such as the Atlantic or Western Ocean, the Indian Ocean, &c.

2. A lake is a tract of water surrounded by land; as the lake of Geneva, the Dead Sea, the Caspian Sea, &c.

3. A bay is a portion or part of the sea running far up the main land; as the Bay of Biscay, Bay of Bengal, &c.

4. A gulf is a part of the ocean almost surrounded with land, save some strait or narrow gut of water, by which it has a communication with the ocean; as the Gulf of Persia, &c.

5. A strait is a narrow passage or part of the sea, which joins one sea to another; as the straits of Gibraltar, which join the Mediterranean Sea to the Atlantic Ocean; the straits of Babelmandel, &c. &c.

S E C T. II.

A further Description of the four Quarters of the World; and,

I. Of EUROPE.

Tyro. **W**HAT are the principal parts into which Europe is divided?

Philo. They are 9 in number; viz. 1. Scandinavia

dinavia (which comprehends Sweden or Swedeland, Denmark, and Norway). 2. Muscovia, or Russia. 3. France. 4. Germany. 5. Poland. 6. Spain. 7. Portugal. 8. Italy. And, 9. Turkey.

Tyro. Pray give me some short account of these with respect to their situation on the globe, and to each other.

Philo. That I will, my dear Pupil; but it must be a short account indeed; just enough to give you a little idea of the matter, and qualify you the better for reading and conversation. But the map of Europe, which you see before you, will be of the greatest use; and the situations of places will be much easier obtained from thence than from any verbal description.

I. Of SCANDINAVIA.

Tyro. What do you mean by Scandinavia; and how, or whereabouts is it situate?

Philo. Scandinavia is a large country, situate between 54 and 72 degrees of N. latitude; under which name are comprehended the kingdoms of Sweden, Denmark, and Norway, as was said before.

I. SWEDEN.

Tyro. How is Sweden situate?

Philo. Sweden is bounded on the N. and W. by Norway, on the E. by Muscovy, and on the S. by the Sound, and part of the Baltic. Its metropolis or chief town is Stockholm, whose distance from London is about $12\frac{3}{4}$ degrees, or 886 miles N. E. The longest day in the
most

ft northern parts of this country is between 2
3 months, and the shortest in the most
thern parts is $6\frac{1}{2}$ hours.

2. DENMARK.

yro. How is Denmark situate?

philo. Denmark is bounded on the N. by the
nd, on the E. by the Baltic, on the S. by
of Germany, and on the W. by the German
an. Its metropolis is Copenhagen, whose dis-
e from London is $8\frac{1}{2}$ degrees, or 590 miles
E. The length of the longest day in the most
thern parts of this country is about $17\frac{1}{2}$ hours;
the shortest in the most southern 7 hours

3. NORWAY.

yro. How is Norway situate?

philo. Norway is bounded on the N. W. and
part of the main Ocean, and on the E. by
len. Its metropolis is Bergen, whose dis-
from London is about $9\frac{1}{4}$ degrees; viz.
miles N. by E. The length of the longest
in the most northern parts is above 2
hs, and the shortest in the most southern
6 hours.

I. Of MUSCOVY or RUSSIA.

yro. How is Muscovy situate?

philo. Muscovy is bounded on the N. by the
Northern Ocean, on the E. by Tartary,
he W. by Sweden and Poland, and on
S. by the Black Sea and Georgia. Its
length is computed to be about 1500 miles,
B 5 and

dinavia (which comprehends Sweden or Swe-
land, Denmark, and Norway). 2. Musco-
or Russia. 3. France. 4. Germany. 5. I-
land. 6. Spain. 7. Portugal. 8. Italy. A
9. Turkey.

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distance from London is about $12\frac{3}{4}$ degrees
or 886 miles N. E. The longest day in the
most

most northern parts of this country is between 2 and 3 months, and the shortest in the most southern parts is $6\frac{1}{2}$ hours.

2. DENMARK.

Tyro. How is Denmark situate?

Philo. Denmark is bounded on the N. by the Sound, on the E. by the Baltic, on the S. by part of Germany, and on the W. by the German Ocean. Its metropolis is Copenhagen, whose distance from London is $8\frac{1}{2}$ degrees, or 590 miles N. E. The length of the longest day in the most northern parts of this country is about $17\frac{1}{2}$ hours; and the shortest in the most southern 7 hours long.

3. NORWAY.

Tyro. How is Norway situate?

Philo. Norway is bounded on the N. W. and S. by part of the main Ocean, and on the E. by Sweden. Its metropolis is Bergen, whose distance from London is about $9\frac{1}{4}$ degrees; viz. 642 miles N. by E. The length of the longest day in the most northern parts is above 2 months, and the shortest in the most southern about 6 hours.

II. Of MUSCOVY or RUSSIA.

Tyro. How is Muscovy situate?

Philo. Muscovy is bounded on the N. by the great Northern Ocean, on the E. by Tartary, on the W. by Sweden and Poland, and on the S. by the Black Sea and Georgia. Its length is computed to be about 1500 miles,

and breadth about 1100 miles. Its chief province is Muscovy, and its ancient metropolis Moscow, whose distance from London is about 23 degrees; viz. nearly 1600 miles N. E. and about 800 E. of Cracow. Its present metropolis is Petersburg. The longest day in the most northern parts of this country is about 2 months, and the shortest in the most southern is about $8\frac{1}{2}$ hours.

III. Of FRANCE.

Tyro. How is France situate?

Philo. France (called Gallia, or the country of the ancient Gauls) is bounded on the N. by the English channel, on the E. by Germany, on the S. by part of Spain and the Mediterranean Sea, and on the W. by the Bay of Biscay. Its length is computed to be 600 miles, and its breadth 500. Its metropolis is Paris, whose distance from London is about 3 degrees S. S. E. viz. 210 miles. The length of the longest day in the most northern part of this kingdom is about $16\frac{1}{4}$ hours, and the shortest in the most southern part 9 hours.

IV. Of GERMANY.

Tyro. How is Germany divided?

Philo. Germany is in length about 700 miles, and breadth about 600. It is divided into three parts; viz. Holland, Flanders, and Upper Germany.

I. HOLLAND.

Tyro. How is Holland situate?

Philo.

Philo. Holland is bounded on the N. and W. by the German ocean, on the E. by Upper Germany, and on the S. by Flanders. Its metropolis in the N. part is Amsterdam, whose distance from London is about 210 miles N. E. and Rotterdam in the S. which is about 190 E. from London.

2. FLANDERS, or the AUSTRIAN NETHERLANDS.

Tyro. How is Flanders situate?

Philo. Flanders is bounded on the N. by Holland, on the E. by Upper Germany, on the S. by France, and on the W. by the German Ocean. It has many fair and rich provinces, the metropolis of which is Brussels, whose distance from London is about 180 miles E.

3. UPPER GERMANY.

Tyro. What do you mean by Upper Germany, and how is it situate?

Philo. Upper Germany, including Switzerland, is that part of Germany properly so called, and part of ancient Gaul and Italy. It is bounded on the N. by Denmark and part of the Baltic, on the E. by Poland, on the S. by Italy, and on the W. by France. Its metropolis is Vienna, whose distance from London is about 760 miles S. E.

V. Of POLAND.

Tyro. How is Poland situate?

Philo. Poland is bounded on the N. and E. by Muscovy, on the S. by Hungary, Transyl-

vania and Turkey, and on the W. by Upper Germany. Its length is about 700 miles, and breadth about 680. Its metropolis is Warsaw, whose distance from London is 13 degrees; viz. about 900 miles E. The longest day in the most northern part of this country is about $17\frac{1}{2}$ hours, and the shortest in the most southern about $8\frac{1}{4}$ hours.

Tyro. Is there any thing else remarkable with regard to Poland?

Philo. The Poles have been lately stript of a great part of their country by the empress of Russia, the emperor of Germany, and the king of Prussia.

VI. Of SPAIN.

Tyro. How is Spain situate?

Philo. Spain, formerly called Iberia or Hesperia, is bounded on the N. by the Pyrenean Mountains and the Bay of Biscay, on the E. by the Mediterranean, on the S. by the Straits of Gibraltar, and on the W. by Portugal and the Atlantic Ocean. Its metropolis is Madrid, whose distance is better than 11 degrees; viz. about 780 miles S. by W. of London. The longest day in the most northern parts of this kingdom is about $15\frac{1}{4}$ hours, and the shortest in the most southern part is about $9\frac{1}{2}$ hours.

VII. Of PORTUGAL.

Tyro. How is Portugal situate?

Philo.

Philo. Portugal is bounded on the N. and E. by Spain, and on the S. and W. by the Atlantic Ocean. Its metropolis is Lisbon, whose distance from London is better than 14 degrees S. W. by S. viz. about 980 miles. The longest day in the most northern parts of this country is about 15 hours, and the shortest in the most southern about $9\frac{1}{4}$ hours.

VIII. Of ITALY.

Tyro. How is Italy situate?

Philo. Italy is bounded on the N. by part of Germany, on the N. E. by the Adriatic Sea, or Gulf of Venice, and on the S. and W. by the Mediterranean and part of France. Its metropolis is the city of Rome, the seat of papacy, and residence of the Pope. Its distance from London is nearly 13 degrees S. E. viz. about 903 miles.

IX. Of TURKEY in Europe.

Tyro. How is Turkey situate?

Philo. Turkey is bounded on the N. by Russia and Poland, on the E. by the Black Sea, and part of Turkey in Asia, on the S. by the Mediterranean, and on the W. by the Gulf of Venice, and part of Germany. It lies between 36 and 49 degrees N. latitude. Its metropolis is Constantinople, whose distance from London is $22\frac{1}{2}$ degrees; viz. about 1564 miles E. by S.

The length of this country is about 1000 miles, and its breadth about 900. The longest day

day in the most northern parts is about 16 hours, and the shortest in the most southern about $9\frac{3}{4}$ hours.

The Division of Turkey.

Tyro. Is not Turkey divided into different parts?

Philo. Yes, into many, but chiefly into five; viz. 1. Hungary. 2. Greece. 3. Romania. 4. Crim and Little Tartary. 5. The Danubian provinces.

I. HUNGARY.

Hungary, though now chiefly subject to the emperor of Germany, is notwithstanding a part of Turkey. It is bounded on the N. by part of Poland, on the E. by Transilvania, on the S. by Slavonia, and on the W. by Austria. Its chief city is Presburg, whose distance from London is about 810 miles S. E.

2. GREECE.

Tyro. How is Greece situate?

Philo. Greece is bounded on the N. by the Danubian provinces, on the E. by Romania and the Ægean Sea, called the Archipelago, on the S. and W. by the Mediterranean. Its chief cities are Athens, Corinth, and Thebes. Corinth is about 54 miles W. of Athens; and Thebes, or Stives, is about 45 N. W. of Athens.

3. ROMANIA.

Romania is bounded on the N. by Bulgaria, on the E. by Greece, on the S. by the Archipelago

lago and the Sea of Marmora, and on the W. by the Black Sea. Its chief cities are Constantinople, the capital, and Adrianople, situate about 146 miles N. W. of Constantinople.

4. LITTLE TARTARY.

Tyro. How are Crim and Little Tartary situate?

Phil. They are bounded on the N. by part of Muscovy, on the E. by Georgia, on the S. by the Black Sea, and on the W. by Poland.

The metropolis is Kassa; it stands near the Euxine Sea, about 400 miles N. E. of Constantinople, and about 750 miles S. of Moscow.

The Turks have lately been deprived of Crim Tartary by the Russians, who have made themselves masters of this part of their dominions.

5. *Of the DANUBIAN Provinces.*

Tyro. What do you mean by the Danubian provinces? and how are they situate?

Phil. They are so called, because they chiefly lie upon, or near the Danube, which rises in the Black Forest in Germany, and falls into the Euxine Sea.

Tyro. How many provinces are there?

Phil. Eight; 1. Transilvania. 2. Walachia. 3. Moldavia. 4. Bulgaria. 5. Servia. 6. Bosnia. 7. Slavonia. 8. Croatia.

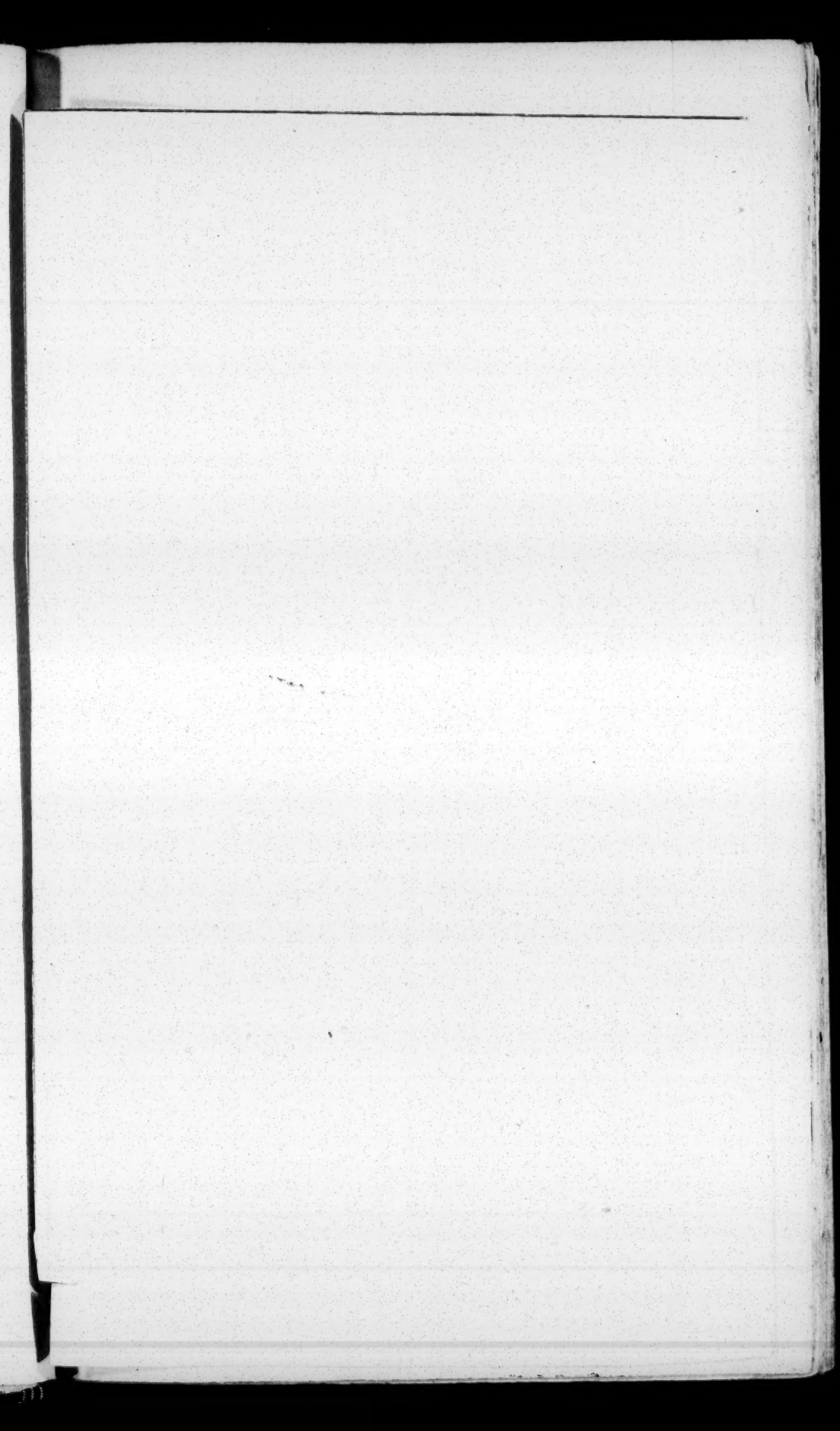
SECT.

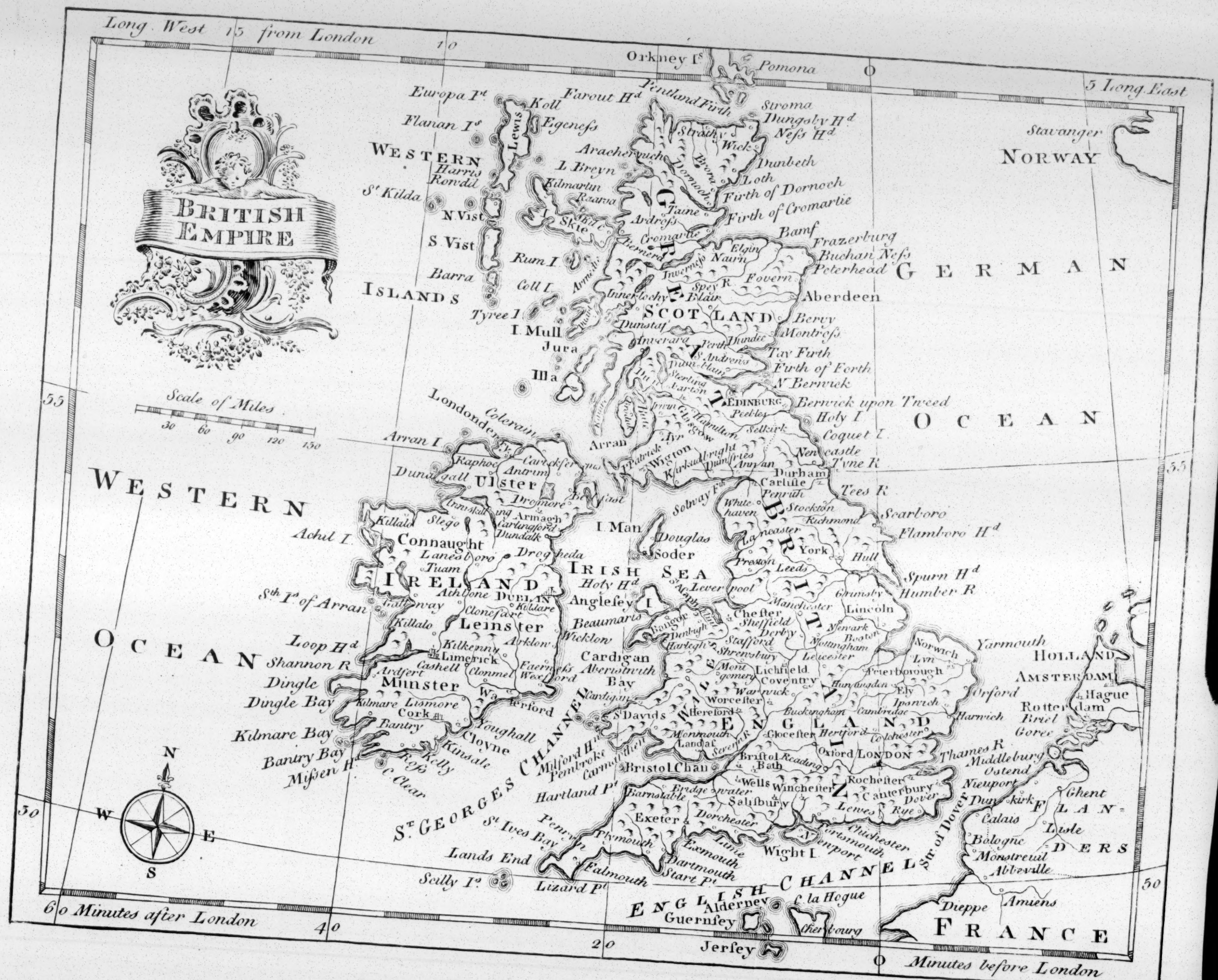
S E C T. III.

*Of the EUROPEAN Islands; and,*I. *Of ENGLAND.**Tyro.* **H**OW is England situate?*Philo.* England (called also Anglia, Britannia, or Albion) is bounded on the N. by Scotland, on the E. by the German Ocean, on the S. by its own Channel, which parts it from France, and on the W. by St. George's or the Irish Sea: it lies between 50 and 56 degrees N. latitude: its length is about 360, and breadth about 300 miles: its metropolis is London.

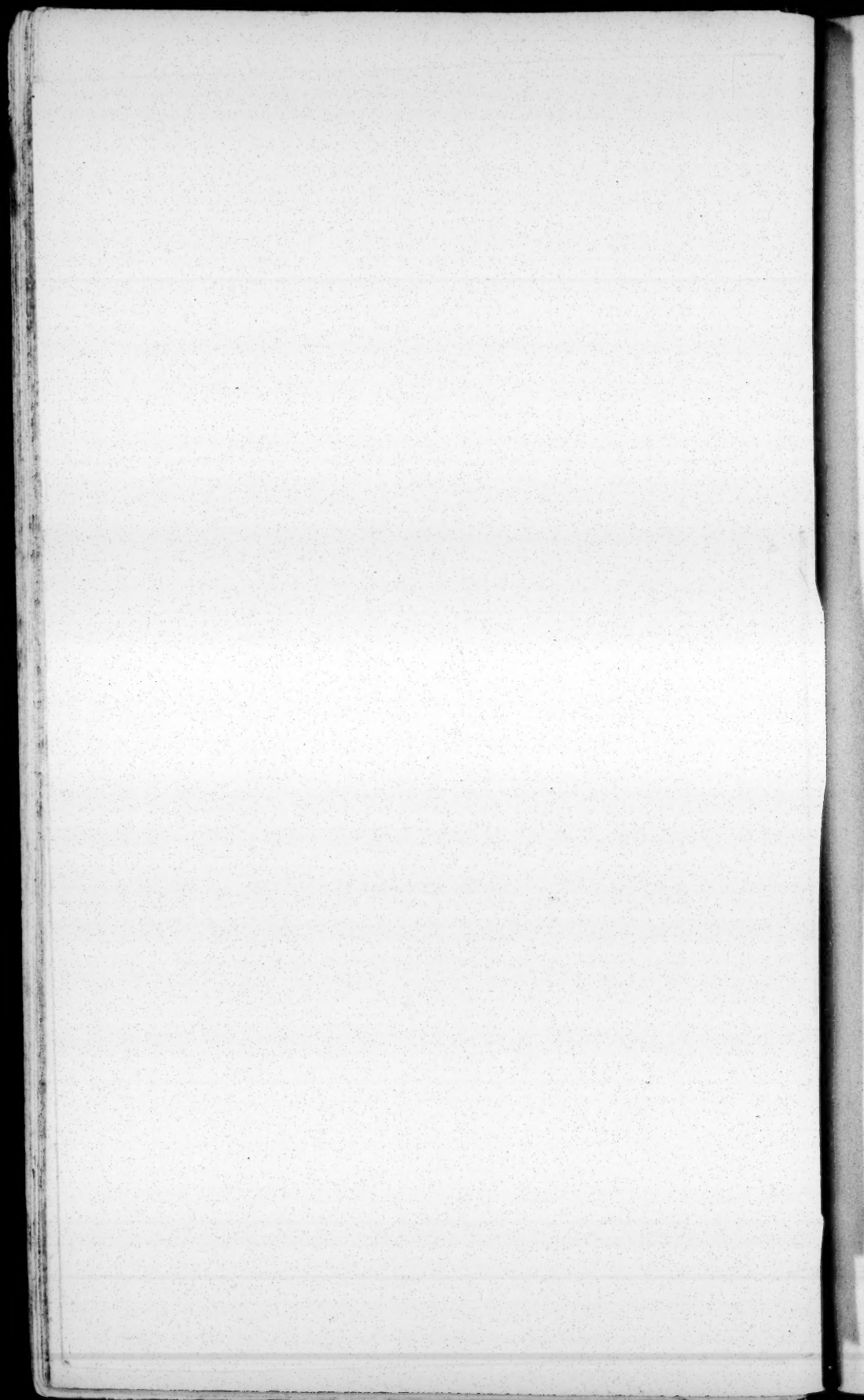
This kingdom contains 38 counties, besides Middlesex and Cheshire; this last being a county palatine, having the privilege of its own particular judges, counsellors, &c. It has two universities, Cambridge and Oxford, 24 bishoprics, and two archbishoprics.

Tyro. Are these all the counties in England?*Philo.* Yes, exclusive of Wales, which has four circuits, twelve counties, and four bishoprics. The longest day in the most northern parts is about $17\frac{1}{2}$ hours, and the shortest in the most southern about 8 hours.II. *Of SCOTLAND.**Tyro.* How is Scotland situate?*Philo.* Scotland (called also Caledonia) is bounded on the N. by the Atlantic Ocean, on the E. by





T. K. Powell sculp.



E. by the German Sea, on the S. by England, and on the W. by the Irish Sea and the Atlantic Ocean. It lies between 54 and 59 degrees N. latitude. Its length is about 300, and breadth about 150 miles, and its metropolis is Edinburgh, whose distance from London is nearly $4\frac{3}{4}$ degrees; viz. about 330 miles N. W. The longest day in the most northern part of this country is about $18\frac{1}{2}$ hours, and the shortest in the most southern $6\frac{1}{2}$ hours.

III. Of IRELAND.

Tyro. How is Ireland situate?

Philos. Ireland (called by some Britannia Parva, and by others Hibernia) is bounded on the N. W. and S. by the Atlantic Ocean, and on the E. by St. George's Channel and the Irish Sea. It lies between 51 and 56 degrees of N. latitude. The length is about 290, and breadth about 150 miles. Its metropolis is Dublin, which is distant from London nearly $4\frac{1}{4}$ degrees; viz. about 295 miles N. W. The length of the longest day in the most northern part is about $17\frac{1}{2}$ hours, and the length of the shortest in the most southern about $7\frac{3}{4}$ hours.

S E C T. IV.

I. *Of the lesser European Islands, and first of such as lie near Great Britain.*

1. *Those on the North are,*

1. **T**HE Orkneys, or Orcades. 2. Shetland.

2. *Those on the East are,*

1. Holy Island. 2. Fern Island. 3. Cocket Island. 4. Shepey Island. And 5. The Isle of Thanet.

3. *Those on the South are,*

1. Portland Island. 2. The Isle of Wight. 3. Portsea Island.

4. *Those on the West are,*

1. Lewis Island. 2. Skye. 3. Mull. 4. Jura. 5. Ila. 6. Bute and Arran. 7. Man. 8. Anglesey. And 9. Scilly.

II. *Of other European Islands, more distant from Great Britain.*

1. *The AZORES.*

These islands lie W. of England, and are subject to the king of Portugal. They are 9 in number; viz. 1. St. Michael. 2. St. Maria. 3. Tercera. 4. Gratiofa. 5. St. George's. 6. Pico. 7. Fyal. 8. Flores. And 9. Cuervo.

2. *Those*

2. *Those of SWEDEN.*

These are 7 in number; viz. 1. Rugen.
2. Oeland. 3. Gothland. 4. Osel. 5. Dago.*
6. Aland. 7. Ween.

3. *Those of DENMARK.*

These are 10; viz. 1. Zealand. 2. Funen.
3. Langland. 4. Laland. 5. Falster. 6.
Mona. 7. Femeren. 8. Alfan. 9. Iceland.
And 10. Bornholm.

4. *Those of NORWAY.*

These are 4; viz. 1. Carmen. 2. Hitteren.
3. Sanien. 4. Weroy.

5. *MEDITERRANEAN Islands.*

Tyro. How many islands go under this name?
and how are they situate?

Philo. There are a great many islands, which
are situate S. of Europe, in or near the Medi-
terranean Sea; but the following are most
noted; viz. 1. Yvica. 2. Minorca. 3. Majorca,
situate E. of Valencia in Spain. 4. Corfica.
5. Sardinia, lying S. of Genoa. 6. Malta.
7. Sicily, lying S. W. of Naples. 8. Candia.
9. Rhodes, And 10. Cyprus. S. E. of Natolia.

The other small islands, as I have observed,
are of little or no consequence. Thus much
for Europe.

Tyro. I heartily thank you, sir; and now pray
give me some little idea of the other parts of
the world.

Philo. I will, but it must be but a short hint
indeed; though I am willing you should have

as

* Osel and Dago are now subject to Russia.

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* Osel and Dago are now subject to Russia.

as much instruction as this small tract will allow of. Proceed we then to

D I A L O G U E II.

S E C T. I.

Of A S I A.

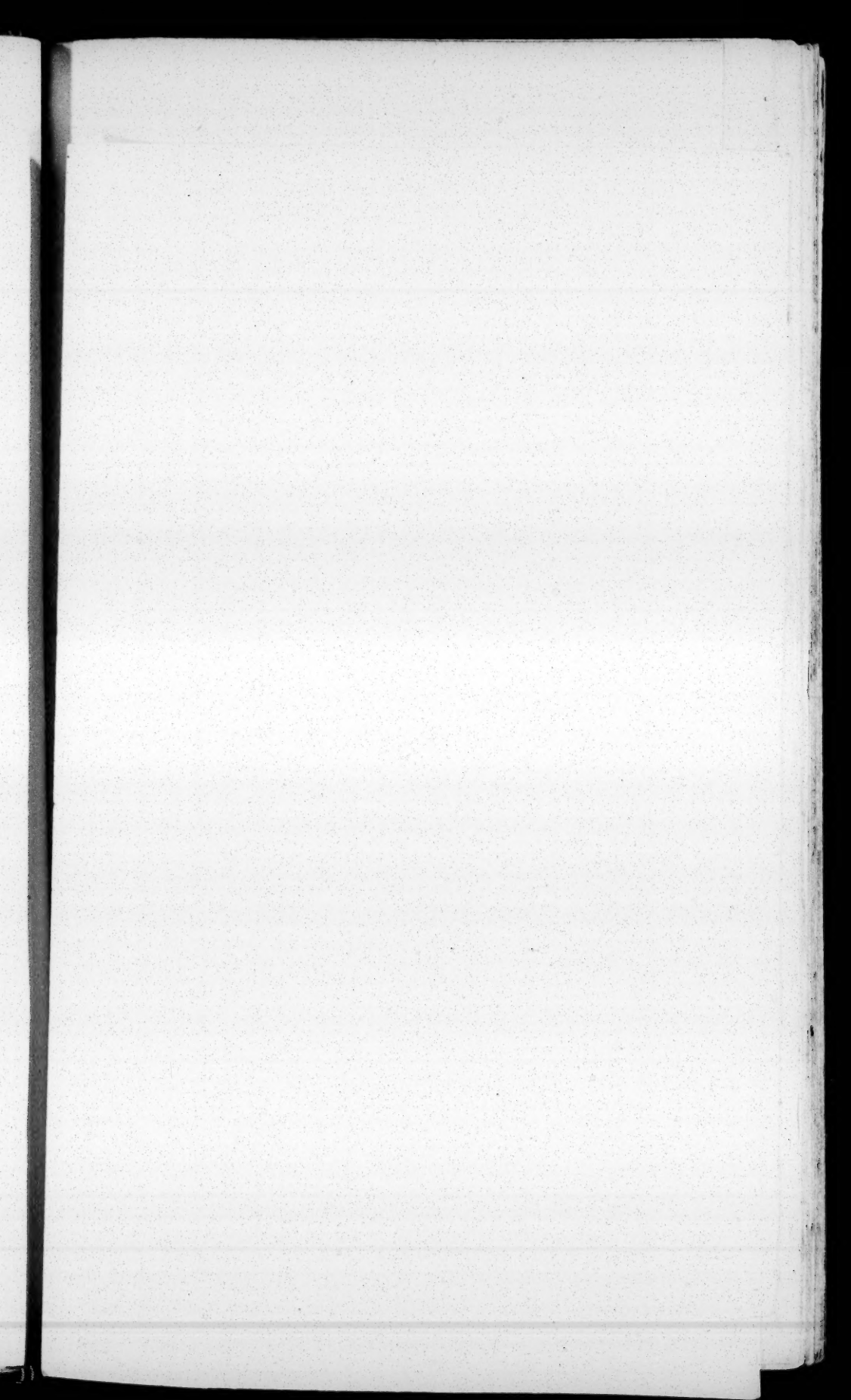
Tyro. **I**N what part of the globe is Asia situate?

Philo. Asia, though called the second, yet is the principal quarter of the globe, lying to the E. of Europe. It extends from the equator to 72 degrees N. latitude, and is divided into 5 principal parts; viz. 1. Tartary. 2. China. 3. India. 4. Persia. And 5. Turkey. These parts, as well as the chief subdivisions, are accurately laid down in the map of Asia, which you see before you, and which you should often consult with attention.

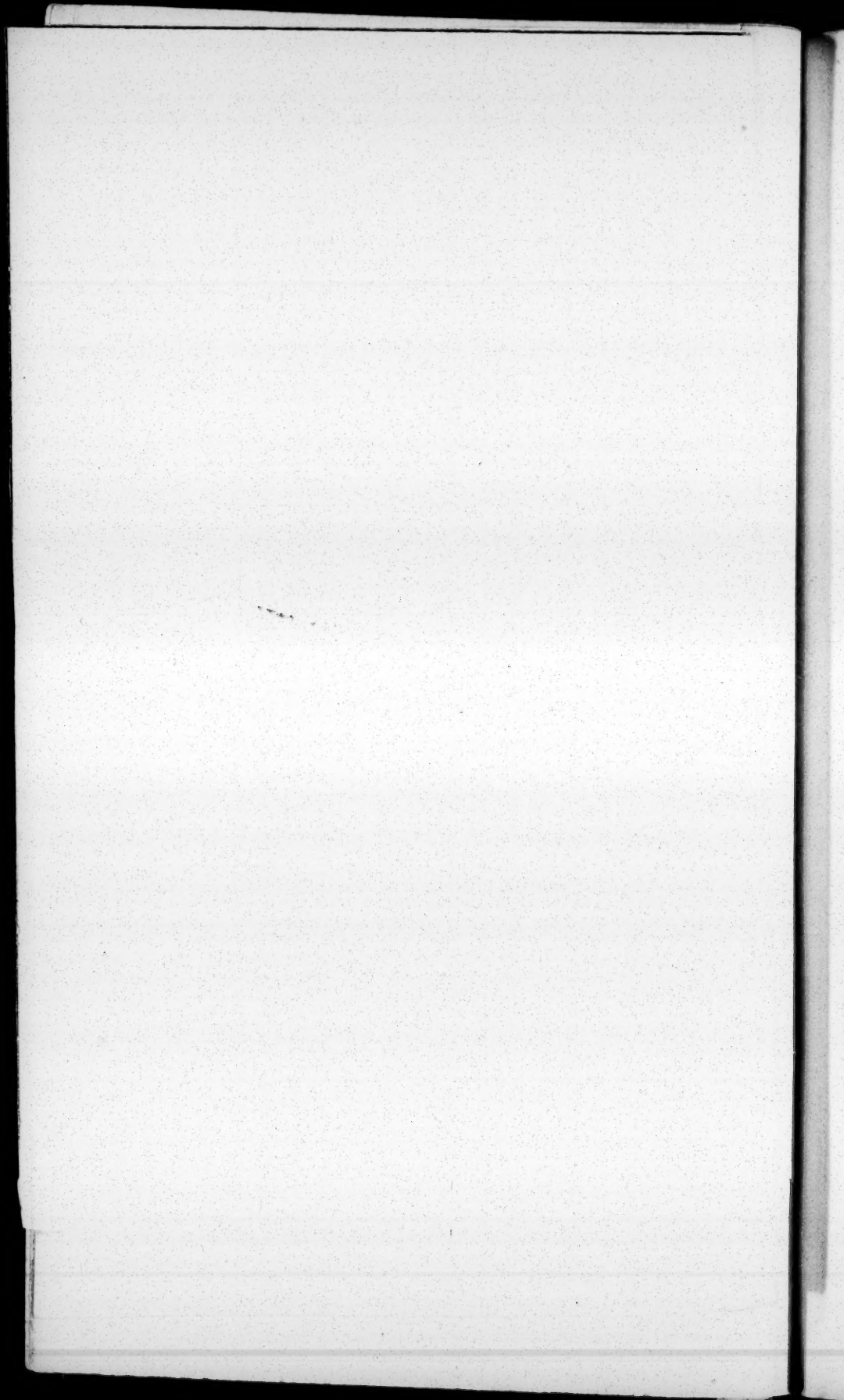
I. Of TARTARY.

Tyro. How is Tartary situate?

Philo. Tartary is bounded on the N. by the Frozen Sea, on the E. by the Pacific Ocean, on the S. by China, India, Persia, and the Caspian Sea, and on the W. by Russia. It lies between 35 and 72 degrees N. latitude, and between the 5 and 26 N. climates; is about 3400 miles long, and 2250 broad, and its chief city is Samarcand. The longest day in the most northern part is about 2 months, and the shortest







shortest in the most southern about $9\frac{3}{4}$ hours. Part of it is subject to the neighbouring nations; viz. the Russians, Turks, and Chinese, and the rest to the Great Khan of Tartary.

2. Of CHINA.

Tyro. How is China situate?

Philo. China is bounded on the N. by part of Tartary, on the E. by the Pacific Ocean, on the S. by part of the Indian Ocean, and on the W. by India without the Ganges. It lies between the 3d and 6th N. climates, is about 1400 miles long, and 1260 broad, and its chief city is Pekin, whose distance from London is 73 degrees; viz. about 5070 miles S. E. From Pekin to Nankin is about 690 miles S. E. in the former of which is a bell, 11 feet diameter, and 12 feet high, weighing 120,000 pounds. The longest day in the most northern part is about 15 hours; and the shortest in the most southern is about $10\frac{3}{4}$. It is under the government of its own emperor.

3. Of INDIA.

Tyro. How is India situate?

Philo. India is bounded on the N. by Tartary, on the E. by China and the Chinese Sea, on the S. by the Indian Ocean, and on the W. by the same Ocean and Persia. It lies between the Equator and 34 degrees of N. latitude. Its length is about 4000 miles, and its breadth about 2500. It is divided into two grand parts; viz. 1. India within the Ganges, or the Great Mogul's

Mogul's empire, containing Delhi (his imperial seat) Agra, Cambaia, Bengal, the Decan, Golconda, Bishnagar, and Malabar.

2. India without the Ganges, whose chief kingdoms are Pegu, Tonquin, Cochinchina, Siam, and Malacca. Length of days and nights, in the northern parts, nearly the same as in China.

4. Of PERSIA.

Tyro. How is Persia situate?

Philo. Persia is bounded on the N. by the Caspian Sea, on the E. by India, on the S. by the Persian Gulf, and Indian Ocean, and on the W. by Asiatic Turkey. It lies between 25 and 45 degrees of N. latitude, and between 44 and 70 E. longitude. It reaches from the 3d to the 7th N. climate; therefore must of course be exceeding hot for many months in the year. Its length is computed at about 1400 miles; its breadth at 1250. It is divided into three parts, N. middle, and S. It is governed by the despotic power of the Great Sophy. The people are chiefly Mahometans. The longest day in the most northern parts is about $15\frac{3}{4}$ hours, and the shortest in the most southern about $10\frac{1}{4}$ hours.

5. Of TURKEY in ASIA.

Tyro. How is Turkey in Asia situate?

Philo. Turkey in Asia (including Arabia) is bounded on the N. by the Black Sea, on the E. by Persia, on the S. by part of Africa, and part of the Indian Ocean, on the W. by the Red Sea, the

the Mediterranean, and the Archipelago. It lies between 12 and 46 degrees of N. latitude; is computed about 2300 miles long, and 2000 broad. It contains six great parts; 1. Natolia, whose chief city is Burfa. 2. Arabia, whose metropolis is Mecca. 3. Syria, whose capital is Aleppo. 4. Diarbeck, whose chief city is Bagdat. 5. Turcomania, whose capital is Arzerum. And 6. Georgia, whose metropolis is Teflis. This vast country is inhabited by Christians, Mahometans, Jews, &c. but is chiefly under the Ottoman yoke.

S E C T. II.

Of the Asiatic Islands.

Tyro. **H**OW many islands are here, and how are they situate?

Philo. There are a great number, but they are chiefly reduced to these six, whose situation is as follows; 1. Japan Islands, E. of China. 2. The Philippine Islands, S. W. of Japan. 3. The Moluccas, S. of the Philippine. 4. The Sunda, W. of the Moluccas. 5. The Banda, or Nutmeg Islands. And 6. Ceylon, W. of the Sunda, whose capital is Candia, or Candy. And thus much for Asia.

D I A-

DIALOGUE III.

SECT. I.

Of AFRICA.

Tyro. **H**OW is Africa situate?

Philo. Africa, the 3d quarter of the world, and situate S. on the globe, is almost surrounded by the Mediterranean Sea, by the Atlantic, Ethiopian, and Indian Oceans, and is extended from 35 degrees of S. latitude, to about 37 N. It is principally divided into 8 Parts; viz. Egypt, Barbary, Biledulgerid, Zaara, called the Defart, Negro-Land, Guinea, Nubia, and Ethiopia, besides Islands.

I. Of EGYPT.

Tyro. How is Egypt situate and divided?

Philo. Egypt is bounded on the N. by part of the Mediterranean Sea, on the E. by the isthmus of Suez and the Red Sea, on the S. by Nubia, on the W. by Barbary and the Desert. It was formerly called Misraim. It is divided into Lower Egypt, whose metropolis is Grand Cairo; and Upper Egypt, whose capital is Sayd. It lies between 21 and 31 N. latitude, and the 2d and 4th N. climates, is about 650 miles long, and 150 broad. It is governed by a Bassa, sent thither by the Turkish emperor: his residence is at Grand Cairo.

2. Of BARBARY.

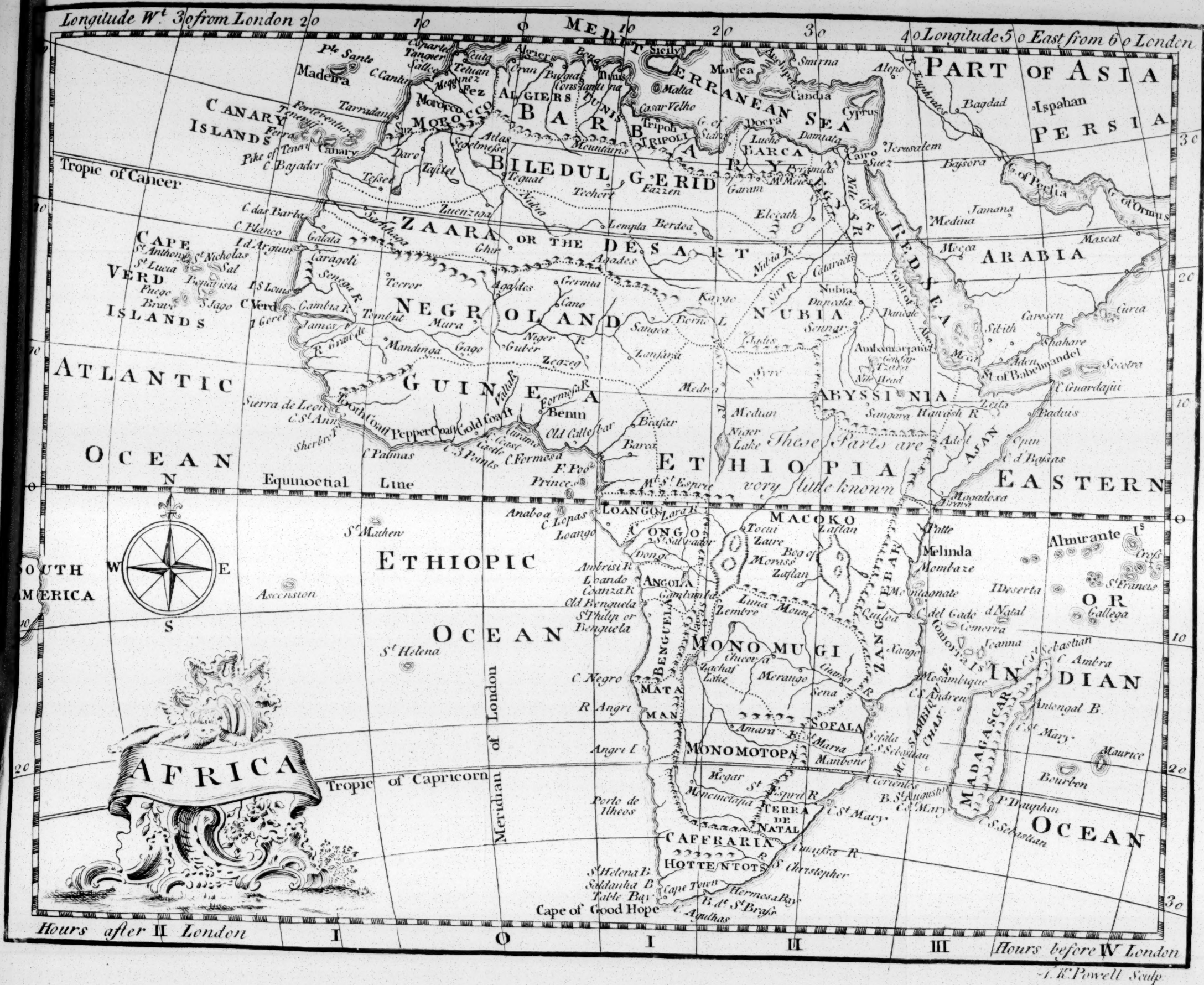
Tyro. How is Barbary situate?

Philo. Barbary is bounded on the N. by part
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of the Mediterranean, on the E. by Egypt, on the S. by Biledulgerid, and on the W. by part of the Atlantic Ocean. It extends from 29 to 37 degrees of N. latitude, and lies under the 4th and 5th N. climate. Its length is 2300, and breadth 380 miles.

Barbary is divided into 7 different parts, or states; viz. Morocco, Fez, Telenfin, Algiers, Tunis, Tripoli, and Barca, whose chief towns are of the same name.

It is chiefly under the government of the Grand Turk, and of the emperor of Morocco, who is called also emperor of Africa, king of Morocco, Fez, Sus, and Tassale; lord of Gago, Dara, and Guinea, and Great Zeriff of Mahomet, and, consequently, their religion is Mahometism. The longest day is $14\frac{1}{4}$ hours, and the shortest $10\frac{1}{2}$ hours, as in Egypt.

3. Of BILEDULGERID.

Tyro. How is Biledulgerid situate?

Philo. Biledulgerid is bounded on the N. by Barbary, on the E. by Egypt, on the S. by Zaara, and on the W. by part of the Atlantic Ocean. It lies between 26 and 29 degrees of N. latitude, and under the 3d and 4th N. climate. Its length is about 2050, and breadth 300 miles. The length of days is from 14 hours to $10\frac{1}{4}$ hours. It is governed by many little kings, but all subject to the Great Turk, or to the emperor of Morocco. The whole of Africa I have laid down on a map, in order

der to give you a true idea of its form, divisions, and principal places.

4. *Of ZAARA, or the DESART.*

Tyro. How is this Defart situate?

Philo. Zaara is bounded on the N. by Biledulgerid, on the E. by Egypt and Nubia, on the S. by Negro-Land, and on the W. by the Atlantic Ocean.

It is divided into 7 parts; viz. Borno, Gago, Bardoa, Lempta, Targa, Zuenziga, and Zanhaga, whose capital is Targassa; the others have the same names as their provinces. It lies between 15 and 26 degrees of N. latitude, and under the 3d and 4th climate; is in length 2340 miles, and breadth about 330. The days are from $13\frac{1}{4}$ long, to $10\frac{3}{4}$ hours. Their government is by several lords and kings, called Xeques, and they are chiefly Mahometans.

5. *Of NEGRO-LAND.*

Tyro. How is the land of Negroes situate?

Philo. Negro-Land is bounded on the N. by Zaara, on the E. by Nubia, on the S. by Guinea, on the W. by part of the Atlantic Ocean. It lies between 8 and 22 degrees of N. latitude, and under the 2d and 3d N. climate. It is computed to be about 2280 miles long, and 600 broad. It is divided into 13 provinces; viz. Genohoa, Gelata, Tombut, Agades, Cano, Cassena, Guangara, Melli, Mandinga, Gaga, Guber,

Guber, Zegzeg, and Zanfara, whose capitals are of the same name. The days are very little different in length from those in Zaara. It is governed by several kings, but all, or most, are subject to the king of Tombut. Gross idolatry and Mahometism prevail here.

6. *Of GUINEA.*

Tyro. How is this country situate?

Philo. Guinea is bounded on the N. by Negro-Land, on the E. by Ethiopia Exterior, on the S. by the Ethiopian Ocean, and on the W. by the Atlantic Ocean. It is divided into 4 parts; 1. The coast of Maleguette, whose capital is Timan. 2. The Ivory Coast westward, whose metropolis is Toba. 3. The Golden Coast eastward, whose capital is St. George de Mina. And 4. The kingdom of Benin, metropolis Arda. Guinea lies between 5 and 13 degrees of N. latitude. Its length is 1320, and breadth about 400 miles. It is subject to the emperor of Guinea, and Paganism is here the prevailing superstition. Their days are from $12\frac{3}{4}$ hours to $11\frac{3}{4}$ hours.

7. *Of NUBIA.*

Tyro. How is Nubia situate?

Philo. Nubia is bounded on the N. by Egypt, on the E. by Ethiopia Exterior, on the S. by Ethiopia Interior, on the W. by part of Zaara and Negro-Land. It lies between 14 and 22 degrees of N. latitude, and under the 2d and

3d N. climate. Its length is about 840, and breadth about 570 miles. The river Nile runs through it, and the principal towns known to the Europeans are Sinnar, and Dangola.

It is governed by its own independent prince. Their traffic is chiefly to Grand Cairo. The length of the days is much the same as in Zaara.

8. Of ETHIOPIA INTERIOR.

Tyro. How is this country situate?

Philo. Ethiopia Interior, called also the land of the Abyssinians, is bounded on the N. by Nubia, and on the E. S. and part of the W. by Ethiopia Exterior. It lies under the 1st, 2d, and 3d N. and S. climates; and the length is computed at 3600 miles, and breadth about 2200. Ethiopia Interior is divided into 8 provinces: viz. 1. Barnagasso. 2. Tigremahon. 3. Dobassat. 4. Fatigar. 5. Angote. 6. Amara. 7. Beleguanze. And 8. Begamedri. It is governed by its own independent prince, lord, or ruler, called Naggasi, whose government is despotic. He styles himself the beloved of God, (says he sprung from the stock of Judah) the son of the column of Sion, the son of the seed of Jacob, the son of the hand of Mary, the son of Nahu after the flesh, and of St. Peter and Paul after the spirit, &c. &c. The longest day in the most northern parts of this country is about $13\frac{1}{2}$ hours, and the shortest in the most southern $10\frac{1}{2}$ hours.

EXTERIOR.

EXTERIOR.

Ethiopia Exterior is bounded on the N. by Abyssinia, on the E. W. and S. by the Ethiopic and Indian Oceans; and, if to this you add the land of the Hottentots, it extends to near 35 degrees S. latitude. It comprehends the kingdoms of Biafara, Loango, Congo, and Angola; the empires of Monomugi and Monomotopa; and the coasts of the Cafres, Zanguebar, Anian, and Abex. It is governed by various princes, and the people are chiefly gross idolaters and Mahometans. As for the Hottentots, they shew no sign of any devotion, only are very superstitious.

The days are from 12 to 14 hours.

S E C T. II.

Of the AFRICAN Islands.

Tyro. **W**HAT are the principal Islands in Africa?

Philo. There are many small islands, but the most noted are the following; viz. 1. The island of Madagascar. 2. Cape Verde Islands. 3. The Canary. And, 4. the Madeira Islands.

I. MADAGASCAR.

This is a large island, lying S. E. of Ethiopia, and extends from 10 to about 25 degrees of S. latitude; is about 1000 miles long, and 300 broad. It is called by the Portuguese St. Laurence,

rence, because they first discovered it on that day. The inhabitants (except in the eastern part) are chiefly Pagans and Mahometans; and are so governed by their priests (called Om-biaffes) that they are extremely superstitious. Thus, if a child be born upon such a day, they say it is unlucky, and therefore give it to the wild beasts; and, if a woman dies in child-bed, they bury the living child with her, because it is better so (they say) than to live without a mother to take care of it. And thus, by these cruel and absurd practices, their island is very thin of inhabitants. It is under no particular governor.

Cape VERDE islands.

These lie S. W. of Barbary, and N. W. of Guinea, between 13 and 17 degrees N. latitude, and are as follow; 1. St. Anthony. 2. St. Vincent. 3. St. Lucia. 4. St. Nicholas. 5. Insula de Sal. 6. Bonavista. 7. Mago. 8. St. Jago. 9. Insula del Fuego. 10. Bravo. The chief town is St. Domingo. They are subject to Portugal.

3. *The CANARY islands.*

These lie N. of the Cape Verde islands, and between 27 and 29 degrees N. latitude. They are 7 in number; viz. 1. Lancerota. 2. Forte Ventura. 3. Canaria. 4. Teneriffe, famous for its peak. 5. Gomera. 6. Ferro, where formerly the first meridian was fixed by common consent; but now every nation fixes it at its own metropolis. And 7. Palma. They are subject to the king of Spain.

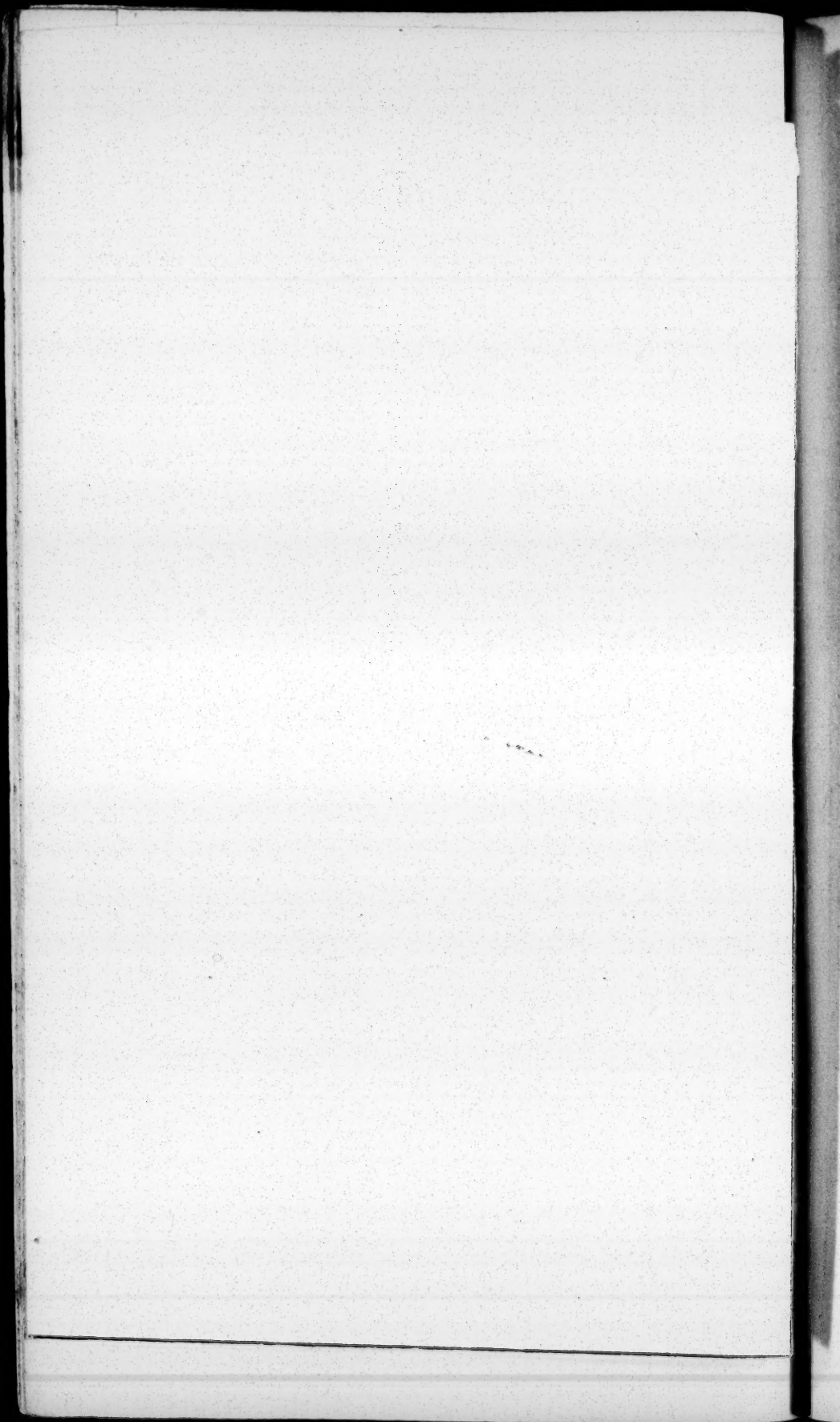
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J. Gibson Sculp



4. MADEIRA, or MADEIRAS.

This lies in about 32 degrees N. latitude, and W. of Morocco. Its chief town is Funchal. It is subject to the Portugueze.

Tyro. Are these all the islands?

Philo. There are some of less note; viz.

1. Zocotora, subject to the Arabians. 2. Comora, N. W. of Madagascar. 3. St. Thomas. 4. Prince's Island. And 5. Annabona, subject to the Portugueze, lying W. of Ethiopia. 6. St. Helena, subject to the English, lying S. W. of St. Thomas's. And 7. The Isle of Ascension, N. W. of St. Helena. Thus much for Africa.

Tyro. I return you thanks, Sir.

Philo. Now, *Tyro*, for the last quarter of the world; viz. America.

DIALOGUE IV.

S E C T. I.

Of AMERICA.

Tyro. **W**HAT is this quarter called, and how is it situate?

Philo. America, called the 4th or last quarter of the world, and westward on the globe.

It is divided into 2 principal parts; one called North, and the other South America. And accordingly I have drawn two maps, one of the former, and the other of the latter;

which will give you adequate ideas of this extensive quarter of the globe.

I. Of NORTH AMERICA.

Tyro. Why is this called North America?

Philo. Because it lies on the N. side of the equator.

Tyro. Into how many principal parts is it divided?

Philo. Into 5, as follows; viz. 1. Mexico, or New Spain. 2. New Mexico, called Granada. 3. Florida. 4. Terra Canadensis. And 5. Terra Arctica.

I. Of MEXICO, or NEW SPAIN.

Tyro. How is this country situate?

Philo. Mexico, discovered in 1518, and conquered by the Spaniards in 1521, is bounded on the N. by Nova Granada, on the E. by the gulph of Mexico, on the W. by the Pacific Ocean, and on the S. by Terra Firma. It lies chiefly in the torrid zone, between 8 and 30 degrees of N. latitude, and is extended to about 33 degrees of longitude. The greatest length is computed to be 2000, and breadth about 600 miles.

Tyro. Into how many principal parts is this country divided?

Philo. Into 3, called Audiences; viz. 1. Guadalajara. 2. Mexico. And 3. Guatimala. The capitals are of the same names as the Audiences.

I. GUADA-

1. GUADALAJARA.

This contains the provinces of Cinaloa, New Biscay, Zacaticas, Guadalajara, Chiameltan, and Zalisco.

2. Mexico contains the provinces of Panuco, Mexico, Mechoachan, Lofs Angelos, Anlequera, Tabasco, and Jucatan.

3. Guatimala comprehends Soco Nufco, Guatimala, Nicaragua, Costa Rica, Veragua, Honduras, Verapaz, and Chiapa. The longest day in the most northern part of this country is about $13\frac{1}{2}$ hours, and in the most southern about $12\frac{1}{2}$ hours. It is governed by the king of Spain, under a viceroy, who resides at Mexico. The Indians are in general idolaters; but the Spaniards, here, as in Europe, are all of the Catholic religion.

2. Of NEW MEXICO, *called* NOVA GRANADA.

Tyro. How is this part of N. America situate?

Philo. This country was discovered by the Spaniards, in 1540, and is bounded on the N. by Terra Arctica, on the E. by Florida, on the S. by Mexico, or New Spain, and on the W. by California. Its extent is not yet known. The chief town is Santa Feé, the residence of the Spanish governor.

3. Of FLORIDA.

Tyro. How is this country situate?

Philo. Florida, discovered also by the Spaniards, 1497, and possessed by them in 1527, is bounded on the North by Georgia, on the E. by the Atlantic Ocean, on the S. by the Gulf of Mexico, and on the W. by the river Mississippi. It lies between 25 and 32 degrees of N. latitude, and under the 5th and 6th N. climate, comprehends 23 degrees of longitude, and is computed to be about 500 miles long, and 440 broad, in its greatest extent.

The natives are gross idolaters. The interior parts are independent: but the places upon or near the sea coasts lately belonged to the English, but, by the treaty of peace in 1783, were ceded to Spain. The longest day in the most northern part is about $14\frac{1}{4}$ hours, and the shortest in the most southern about $10\frac{1}{2}$ hours.

The chief towns are St. Augustine and Pensacola.

4. *Of* TERRA CANADENSIS.

Tyro. How is this country situate?

Philo. It is bounded on the N. by part of Terra Arctica, on the E. by the Atlantic Ocean, on the S. by the Gulf of Mexico, and on the W. by New Mexico and parts unknown. It lies between 30 and 62 degrees of N. latitude, and extends to near 40 degrees of longitude; is about 2100 miles in length, and 1600 in breadth.

Tyro. But pray is it not divided into some principal parts?

Philo.

Philo. Yes, into N. and S. The N. comprehends, 1. Terra Canadensis Propria. 2. Nova Britannia, or New Britain. 3. Nova Francia, New France, or Canada; chief town Quebec. This last now belongs to Great Britain.

Tyro. What does the S. part contain?

Philo. 1. Novo Scotia. 2. New England. 3. New York. 4. The Jerseys. 5. Pensilvania. 6. Maryland. 7. Virginia. 8. Carolina. And 9. Georgia. All these (Nova Scotia excepted) containing, in the whole, 13 provinces, have lately renounced their allegiance to the crown of Great Britain, and, at the conclusion of the last war in 1783, were acknowledged, by the English and by the rest of the world, as sovereign and independent States.

The chief towns of these provinces in order are, 1. Halifax in Nova Scotia. 2. Boston. 3. New York. 4. Elizabeth. 5. Philadelphia. 6. Annapolis Royal. 7. James Town. 8. Charles Town. And 9. Savannah.

1. Nova Scotia, discovered in 1622.

2. New England, in 1497, and possessed for queen Elizabeth, by Sir Philip Amadas, in 1558.

3. New York, by Mr. Hudson, in 1608, and sold to the Dutch, who kept it till 1664; at last it was given by Charles II. to the duke of York; it was called before New Netherland.

4. New Jersey, was discovered in 1497.

5. Pensilvania about the same time. it was given by Charles II. to William Penn, Esq. by letters patent in 1680.

6. Virginia, in 1497, but more particularly in 1584, by Sir Walter Raleigh, who is said to be the first that brought tobacco into England. It was called Virginia, in honour of queen Elizabeth, as a virgin queen.

7. Maryland, was also discovered by the English under the two Cabots, in 1497. It has its name from Mary, wife of Charles I. who gave it by letters patent to the right honourable Cæcilius Calvert, Lord Baltimore, in 1632.

8. Carolina, discovered about the same time, and in 1660 granted by patent to several noblemen, by Charles II.

5. Of TERRA ARCTICA.

Tyro. What do you mean by Terra Arctica?

Philo. This country is called Arctica, because it lies towards the North; it comprehends those parts of America, or lands near America, situate near, or towards, the N. pole, or polar circle.

Tyro. Which are they?

Philo. There are many of them; but the chief and most noted are, 1. Greenland. 2. Spitsbergen. 3. Nova Zembla. 4. Terra de Jessø. 5. New Denmark. And 6. New North Wales.

Little more is known of these at present but their names, and therefore they cannot be taken any further notice of.

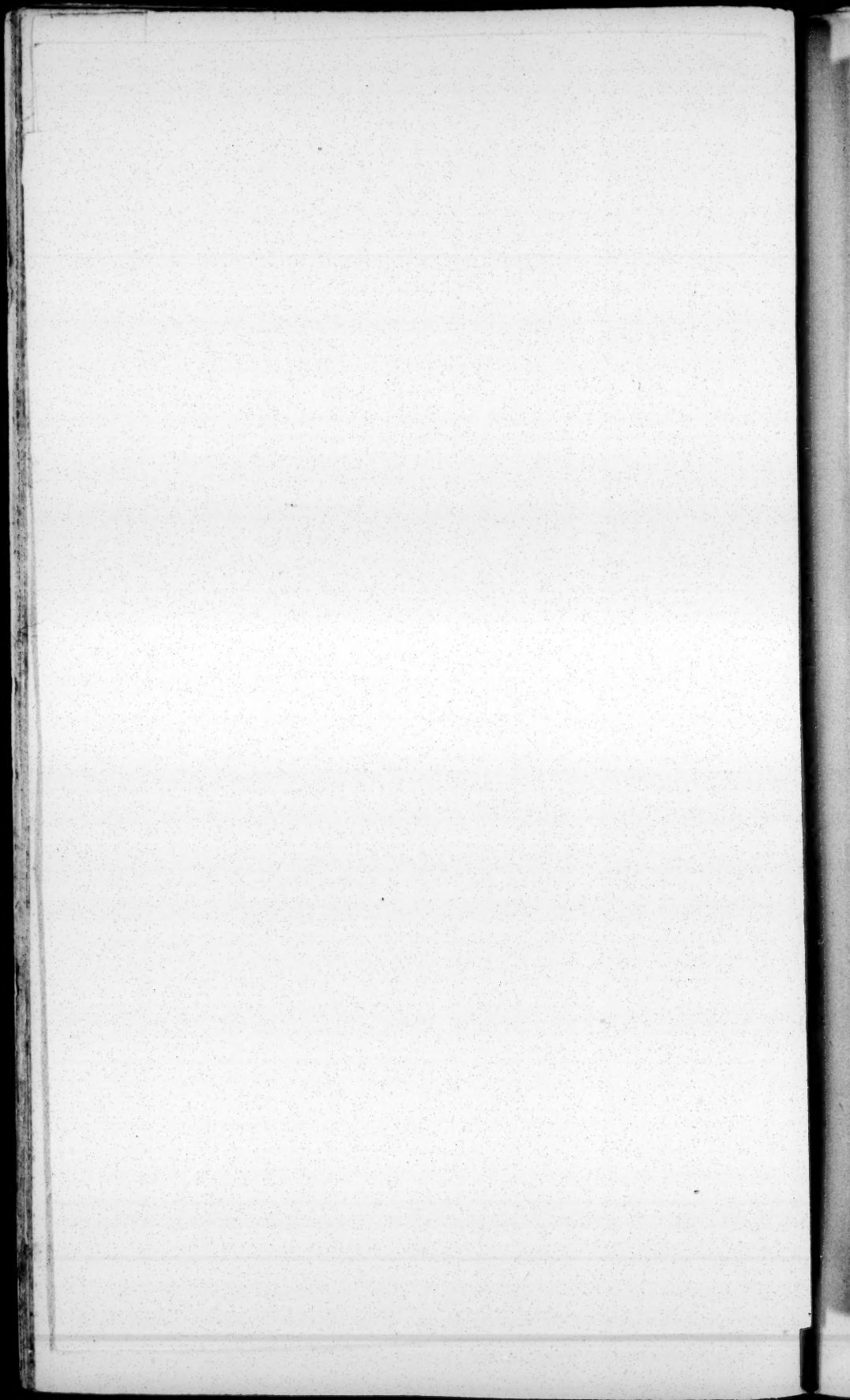
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II. Of SOUTH AMERICA.

Tyro. Why is this so called?

Philo. Because it lies chiefly on the S. side of the equator.

Tyro. Into how many principal parts is it divided?

Philo. Into 7; viz. 1. Terra Firma. 2. Peru. 3. The Land of the Amazons. 4. Brasil. 5. Chili. 6. Paraguay. And 7. Terra Magellanica.

I. Of TERRA FIRMA.

Tyro. How is this situate?

Philo. Terra Firma, discovered in 1514, lies under the 1st N. climate, and is bounded on the N. by the Atlantic Ocean, on the E. by the same, on the S. by Peru and the country of the Amazons, and on the W. by the Pacific Ocean. It is extended to about $27\frac{1}{2}$ degrees of longitude, and lies between the equator and $11\frac{1}{2}$ degrees of N. latitude. It is computed to be about 1500 miles long, and 750 miles broad.

Tyro. How is it divided?

Philo. Into E. and W. The E. upon the river Oroonoke, called Guiana, whose chief towns are Surinam and Cayenne. The W. comprehends the provinces of

1. Panama, called also Terra Firma; chief town is Panama.

2. Carthagena, metropolis the same.

3. St. Martha, metropolis the same.

4. Rio de la Hacha, metropolis the same.

5. Anda-

5. Andaluzia, metropolis St. Thomas.
6. Comana, metropolis Comana.
7. New Granada, metropolis St. Feé de Bagota.
8. Papayan, metropolis Papayan.

It is governed, for the king of Spain, by a viceroy residing at Mexico. The natives of this country, especially in the middle, are gross idolaters.

2. Of PERU.

Tyro. How is this country situate?

Philo. Peru, first discovered by the Spaniards, in 1525, is bounded on the N. by part of Terra Firma, on the E. by Amazonia, on the S. by Chili, and on the W. by the Pacific Ocean. It lies between 24 degrees of S. and 1 degree of N. latitude, and is extended to 20 degrees of longitude, and under the 1st, 2d, and 3d S. climate.

Tyro. How is it divided?

Philo. Into three provinces.

1. Quito, N. whose chief towns are Quito and Payta.

2. Lima, or Los Reyes, in the middle, whose chief towns are Lima, the metropolis, Cusco, and Callao.

3. Los Charcos, S. whose chief towns are Potosi and Porco.

The natives in general are very gross idolaters, worshipping the sun, moon, stars, thunder, lightning, &c. But in some parts there are Christians, &c.

It was conquered by the Spaniards in 1533,
and

and they have the most considerable part of it under their dominion.

3. *Of the Land of the AMAZONS.*

Tyro. How is this land situate?

Philo. This country, discovered by the Spaniards in 1541, is bounded on the N. by Terra Firma, on the E. by Brasil, on the S. by Paraguay, and on the W. by Peru.

It lies under the 1st, 2d, and 3d S. climate. It is under no particular government, the inhabitants in general being a savage sort of people, appearing always in arms. From this circumstance it is supposed to take its name, in allusion to those ancient warlike women the Amazons, who are spoken of by the poets, and by several historians.

4. *Of BRAZIL.*

Tyro. How is Brazil situate?

Philo. This country, discovered by the Portuguese, about 1501, is bounded on the N. and E. by the Atlantic Ocean, on the S. by the mouth of the river Plata, and on the W. by a chain of mountains, which divides it from Paraguay, and the country of the Amazons.

It lies between the equator and 35 degrees of S. latitude, and under the 1st, 2d, 3d, 4th, and 5th S. climate.

Its greatest length is computed to be about 2500 miles, and its breadth about 700.

Tyro. Into how many principal parts is it divided?

Philo.

Philo. There is not any particular account of its provinces, divisions, &c. but the chief towns that are known, or most worthy of note, are as follow: 1. St. Vincent. 2. Sanctos. 3. Angra Dos Reyes. 4. St. Sebastian, or Rio de Janeiro. 5. Spiritu Sancto. 6. Porto Seguro. 7. St. Salvatore. 8. Pernambuco. And 9. Parayba.

The natives are under no particular government, nor profess any religion, being chiefly sunk into gross ignorance, idolatry, &c.

5. Of CHILI.

Tyro. How is this country situate?

Philo. Chili, discovered by the Spaniards about 1554, is bounded on the N. by Peru, on the E. by Paraguay, on the S. by Terra Magellanica, and on the W. by the Pacific Ocean.

It lies between 25 and 44 degrees of S. latitude, and under the 4th, 5th, and 6th S. climate.

Its length is computed to be about 1100 miles, and its breadth 600.

Tyro. Into how many parts is Chili principally divided?

Philo. Into 3; viz. 1. Chili Proper. 2. Chili Imperial. And 3. Chucuito, whose chief towns are St. Jago, Baldivia, and St. John de Fontiera.

It is chiefly governed by the viceroy of Peru, under the king of Spain.

6. Of PARAGUAY.

Tyro. How is Paraguay situate?

Philo. This country, discovered also by the Spaniards

Spaniards in 1546, is bounded on the N. by the land of the Amazons, on the E. by Brazil, on the S. by Terra Magellanica, and on the W. by Chili and Peru.

Tyro. Whence has it its name?

Philo. From the river Paraguay; but it is called by the Spaniards (and currently by others) Rio de la Plata.

It lies between 12 and 37 degrees of S. latitude, and under the 2d, 3d, 4th, and 5th S. climate, and extends to about 25 degrees of longitude.

Its length is computed about 1500 miles, and breadth about 1100 miles.

Tyro. Into how many principal parts is it divided?

Philo. The most material provinces are 5 in number; viz. 1. Guayra, whose chief town is Ciudad Real. 2. Paraguay Proper, whose chief town is Assumption. 3. Chaco, whose chief town is Concepcion. 4. Tucuman, whose chief town is St. Jago. And 5. Rio de la Plata, whose chief town is Buenos Ayres. It is governed chiefly by a viceroy.

Of TERRA MAGELLANICA.

Tyro. How is this country situate?

Philo. It is bounded on the N. by part of Paraguay and Chili, on the E. by the Atlantic Ocean, on the S. by the Straits of Magellan, and on the W. by the Pacific Ocean.

It was discovered about 1519, by one Ferdinand Magellan, from whom it took its name.

SECT.

S E C T. II.

Of the AMERICAN Islands, and NEW DISCOVERIES.

Tyro. **W**HAT are the principal islands of America?

Philo. They are 11, which are thus divided:

- | | | | |
|------------------|---|------------------------|----------------------------------|
| 1. In the North | { | 1. Newfoundland | |
| | | 2. California* | |
| | { | 3. Cuba | |
| | | 4. Jamaica | } Called the
Great Antilles. |
| | | 5. Hispaniola | |
| | | 6. Porto Rico | |
| 2. In the Middle | { | 7. Bermudas | |
| | | 8. Lucayos, or Bahamas | |
| | | 9. Caribbees | |
| | { | 10. Sotovento | } Called the
Little Antilles. |
| | | | |
| 3. In the South, | | 11. Terra del Fuego | |

I. *Of NEWFOUNDLAND.*

This island was discovered by the two Cabots, in the time of Henry VII. 1497; but more perfectly by Thorn and Elcot of Bristol, in 1527. It lies between 46 and 52 degrees of N. latitude, near New Britain.

It is subject to the crown of England. It is chiefly valuable on account of the great cod-fishery upon its banks, which is supposed to employ upwards of 10,000 hands, and to increase the national wealth about 300,000*l.* a year. Chief towns Placentia, Bonavista, and St. John's.

2. *Of*

* Now known to be a peninsula.

2. *Of CALIFORNIA.*

The northern part of this peninsula was discovered by Sir Francis Drake in 1577. It has Mexico on the E. and the Pacific Ocean on the W. It lies between 23 and 43 degrees N. latitude.

3. *Of CUBA.*

This island was discovered by the Spaniards in 1594. It lies N. of Jamaica, N. W. of Hispaniola, and S. of the Bahama islands. It lies between 19 and 23 degrees N. latitude, and extends to about 13 degrees of longitude. It is subject to the king of Spain, and the chief towns are the Havanna and St. Jago.

4. *Of JAMAICA.*

This was discovered by Columbus, and conquered from the Spaniards by Penn and Venables in Oliver Cromwell's time. It was first called St. Jago, but afterwards Jamaica, in honour of James duke of York.

It lies S. of Cuba, and W. of Hispaniola, and between 17 and 19 degrees N. latitude, and extends to about 3 degrees of longitude.

It is subject to the English. Its chief towns are Kingston, Port Royal, and Spanish Town.

5. *Of HISPANIOLA.*

This was discovered also by Columbus in 1492. It lies between 17 and 21 degrees of N. latitude. It has Cuba on the N. W. Jamaica on the W. and Porto Rico on the E. The western

western part is subject to France, the eastern to Spain. Its principal town is St. Domingo, in possession of the Spaniards.

6. *Of Porto Rico.*

Porto Rico (once called *Johannis Insula*, and by the natives *Bonquin*) lies E. of *Hispaniola*, in about 18 degrees N. latitude. It is called *Porto Rico* from the city and haven of the same name. It is subject to Spain.

7. BERMUDAS.

Bermudas, so called from John Bermudas, a Spaniard, who first discovered it. It lies between 32 and 33 degrees of N. latitude, about 240 English leagues E. of Carolina; and is subject to the crown of Great Britain.

8. *Of the LUCAYOS.*

Tyro. Why are these so called?

Philo. From *Lucayos*, the longest of them all. They extend from the coast of Florida, to the N. of *Hispaniola*.

The chief of them are, 1. *Bahama*. 2. *Lucayos*. 3. *Providence*. 4. *Cignatio*. 5. *Guana-hani*. 6. *Tuma*. 7. *Tama*. 8. *Samana*. And 9. *Maiaguana*.

The principal of these is *Bahama*, near Cape Florida, and remarkable for spiders, they being about 2 inches long, and having, in general, 6 eyes.

9. *Of the CARIBBEE Islands.*

Tyro. Why are these islands so called?

Philo.

Philo. From the inhabitants, who, upon the first discovery, were found to be cannibals. They represent the segment of a circle, are about 30 in number, and extend from about 17 degrees N. almost to Terra Firma.

The chief among them are, 1. Anguila. 2. St. Martin. 3. Sancta Crux. 4. Barbuda. 5. St. Christopher's. 6. Nevis, or Mevis. 7. Antego. 8. Montserrat. 9. Guadalupe. 10. Marigalant. 11. Dominica. 12. Martinico. 13. St. Lucia. 14. Barbadoes. 15. St. Vincent. 16. Granada. And 17. Tobago.

Note, Some of these belong to the English, some to the French, and others to the Dutch. One of the most considerable of them is Barbadoes, in about $13\frac{1}{2}$ degrees N. latitude. It is subject to the English. Metropolis Bridge Town.

10. *Of the SOTOVENTO.*

These are so called by the Spaniards, to whom they chiefly belong, and are found from E. to W. along the coast of Terra Firma. The principal of them are, 1. Trinidad. 2. Margarita. 3. Tortuga. 4. Orchilla. 5. Rocca. 6. Bonayre. 7. Curaçoa. And 8. Aruba.

11. *Of TERRA DEL FUEGO.*

This (according to several historians) is so called, on account of several volcanos. It is situate S. of Magellanica, and parted from the continent by the Straits of Magellan, lying between 52 and 56 degrees S. latitude.

NEW

NEW DISCOVERIES.

Of late years several voyages have been performed round the world, particularly by the celebrated Captain Cooke; and, in the course of these, some new islands have been discovered, and the coasts of others more perfectly explored. The principal of those newly discovered are, Otaheite, the Society Islands, Oteroa, the Friendly Islands, the New Hebrides, New Caledonia, the Marquesas, the Pelew Islands, and the Sandwich Islands; at one of the latter, called Owhyhee, Captain Cooke was unfortunately killed, Feb. 14, 1779.

Those more perfectly explored are, New Guinea, New Zealand, and New Holland. The latter is, by much, the largest island in the world; on the east coast of which, called New South Wales, is Botany Bay, the place to which the convicts are now transported. Distant from London 10,500 miles, S. E.

The first convicts destined for Botany Bay (being 750 in number) sailed from Portsmouth on Sunday the 13th of May, 1787, and arrived at Botany Bay in January, 1788.

Thus, *Tyro*, I have given you as complete a view of Geography as I could in so narrow a compass; and I hope it will be sufficient to excite the curiosity of young beginners, and to qualify them in time for understanding those authors that have treated more largely and particularly on the subject.

And now, *Tyro*, we are come to the use of the Globes.

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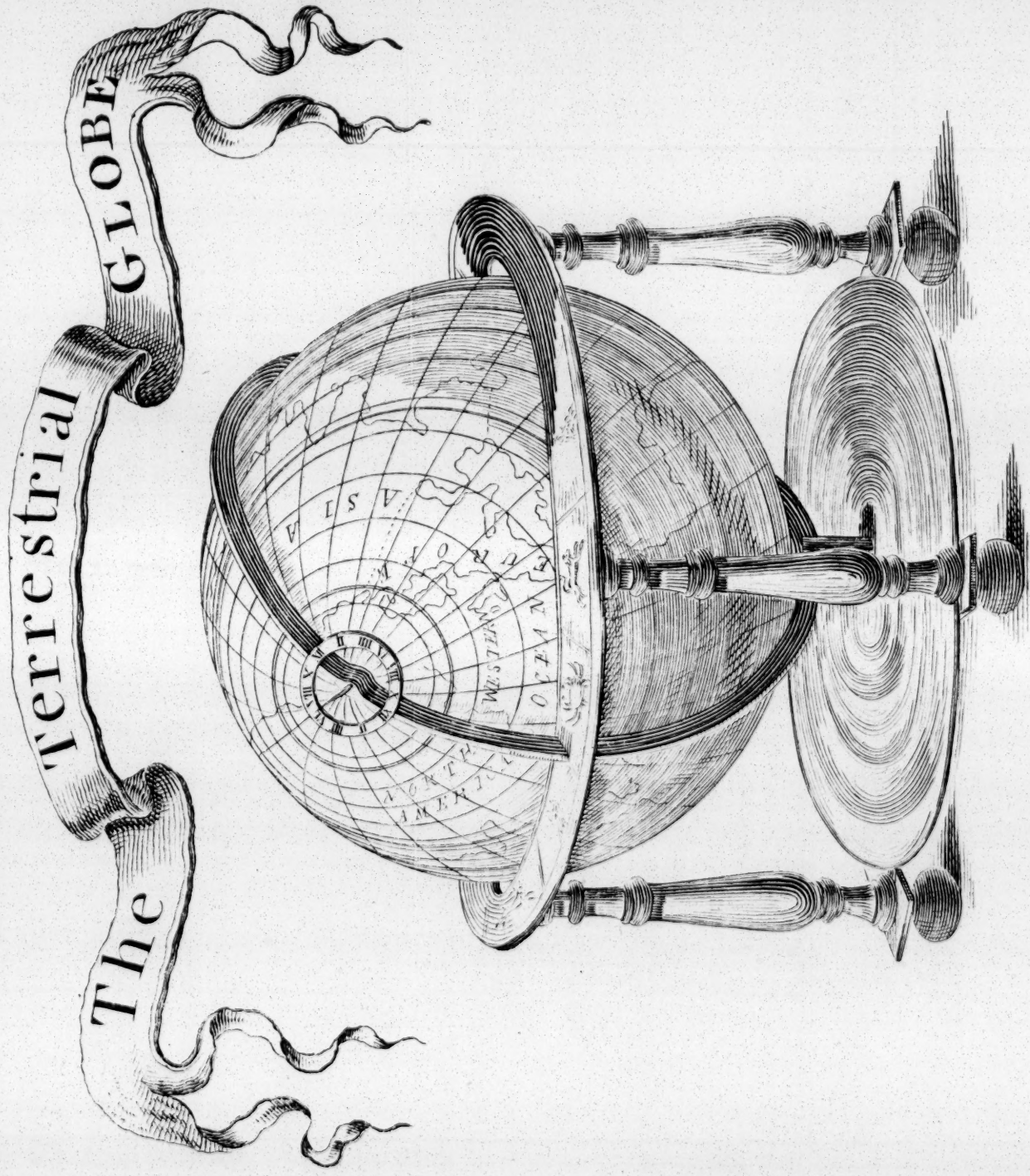
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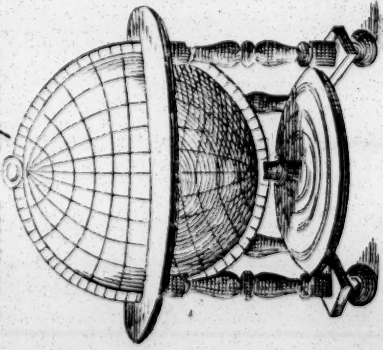


*For half the SCHOOL Authors be Read, it will be seasonable for YOUTH to learn
the Use of the GLOBES.*

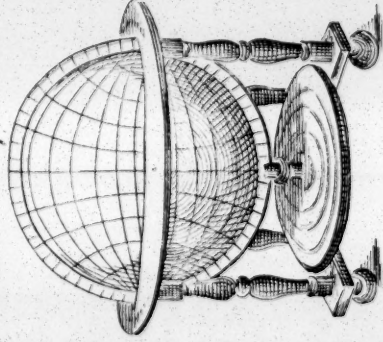
MILTON on Education.

The GLOBE or Sphere in its Three Different Positions.

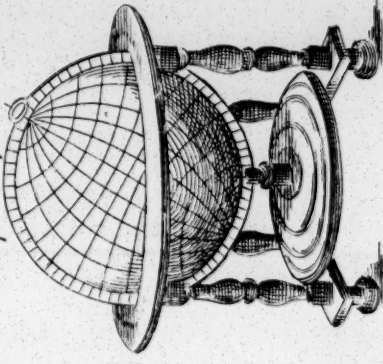
Parallel Sphere.



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D I A L O G U E V.

Between PHILO, a Tutor, and TYRO, his Pupil, concerning the nature, properties, and use of the GLOBES.

S E C T. I.

Tyro. **W**HAT is a globe, or sphere?

Philo. A globe, or sphere, is a solid round body, contained under one surface; having a point in the middle, called the centre, from whence all lines drawn to the surface are equal.

Tyro. Pray, how is a globe generated or formed?

Philo. It is made by the rotation of a circle, or semi-circle, broad ways upon its axis: thus, a shilling pressed upon its edge, by two pins opposite each other, and blown round, will naturally represent the formation, or shape of a globe.

Tyro. How many sorts are there?

Philo. Two, one called the Terrestrial, or earthly; the other the Celestial, or heavenly globe.

Tyro. What does the Terrestrial globe teach us?

Philo. By the Terrestrial globe we are taught the knowledge of the earth and sea; with the situation of places, their difference in latitude and longitude; the sun's rising and setting; the length of days and nights throughout the year,
and

and the true distance from one place to another. This is called Geography.

Tyro. What is the use of the Celestial globe?

Philo. The Celestial globe not only teaches us the sun's rising and setting, but also the rising and setting of the stars, together with their right Ascension, Declination, Amplitude, Almacanther, Azimuth, Latitude, Longitude, and Distance from each other. This is called Astronomy.

Tyro. But I must know first what Almacanther, Azimuth, &c. mean.

Philo. That you shall know by and by: but first you must learn the names of the appendants and different circles belonging to the globe.

Tyro. Please then to let me know what they are.

Philo. I will; and only take a little pains to learn the nature of them, and you will soon be qualified to work some problems yourself.

S E C T. II.

A further description of the GLOBES, with the great circles and appendants belonging to them.

Tyro. **W**HAT do you mean by great circles of the sphere?

Philo. Great circles are such as cut the globe into two equal parts, passing through the centre: all such as do not cut the sphere into two equal parts, are called lesser circles.

Tyro.

Tyro. Pray how many great circles are there?

Philo. 1. The Equator, or Equinoctial. 2. The Ecliptic, or Zodiac. 3. The Brazen Meridian. 4. The Horizon. And 5. The Colures.

I. *Of the EQUATOR.*

Tyro. What is the Equator, or Equinoctial?

Philo. The Equator on the Terrestrial, or Equinoctial on the Celestial Globe, is a line, or circle, that cuts the Globe into two equal parts, called northern and southern hemispheres, whose poles are those of the world, dividing the N. from the S. and upon the Globe it is easily known by two broad lines running parallel to each other, and a fine hair line between them: it is divided into 360 equal parts, called degrees, beginning, on the Celestial Globe, at the first meridian (or sign Aries) and is marked from 1 with 10, 20, 30, 40, &c. to 360, quite round. The first meridian on the Terrestrial Globe, as I have already observed, was formerly fixed at the island of Ferro; but now almost every nation fixes it at its own metropolis.

Tyro. But there are other figures on the lower edge, or part, of the Equator on the Terrestrial Globe; are there not?

Philo. Not on all Globes. Senex's Globes, indeed (which, as I said before, I would recommend) are also marked from the meridian of London, with 10, 20, 30, &c. to 180 degrees to the right-hand, or E. and, in like manner, towards the left-hand from London, with 10, 20, 30, &c. to 180, W.

D

Tyro.

Tyro. And, pray, what is the use of this?

Philo. The Equator shews you the longitude of any place, either E. or W. from the first meridian; and this lower line on Senex's Globe shews you the longitude of any place from London, which is extremely convenient. The upper line of figures on the Equinoctial shews the right and oblique ascension of the sun, or any star.

2. Of the ECLIPTIC and ZODIAC.

Tyro. What, or which is the Ecliptic?

Philo. The Ecliptic is another great circle of the sphere, whose poles are in the polar circles, where it is intersected by the *solstitial Colure*, running from Cancer south, and from Capricorn northward. It cuts the Equator at the two points Aries and Libra, making an angle at each point of 23 degrees, 30 minutes, which is its furthest, or utmost extent, either N. or S. from the Equator, as you will see more plainly hereafter.

Tyro. What is the Zodiac?

Philo. The Zodiac is a broad imaginary circle, which extends itself (according to the rules of Astronomy) eight degrees on each side of the Ecliptic, and is that which contains the 12 signs, and in which the planets perform their revolutions. The line in the middle of the Zodiac, is called the Ecliptic; because Eclipses happen in or near that line. It is called *Via Solis*, the Sun's path, or way. ¶ But in Astronomy, it is that circle, or path, which the earth would

would describe to an eye, placed in the centre of the system, viz. the sun.

Tyro. Pray, Sir, tell me in what manner the Ecliptic is divided, for, I think, I have some notion of it.

Philo. The Ecliptic (like the Equator) is divided into 360 degrees, but not numbered from 1, 10, &c. as the Equator is. It is divided into 12 equal parts, containing 30 degrees each, which are called Signs, and have different names and characters.

Tyro. Please to let me know them.

Philo. I will; and you must mind to get the names of them by heart, and the character belonging to each, so as to know them at first sight.

The S I G N S.

NORTHERN SIGNS.

<i>Aries.</i>	<i>Taurus.</i>	<i>Gemini.</i>	<i>Cancer.</i>	<i>Leo.</i>	<i>Virgo.</i>
♈	♉	♊	♋	♌	♍

SOUTHERN.

<i>Libra.</i>	<i>Scorpio.</i>	<i>Sagittarius.</i>	<i>Capricornus.</i>	<i>Aquarius.</i>	<i>Pisces.</i>
♎	♏	♐	♑	♒	♓

☞ Take notice, the first six are called the Northern, the other the Southern Signs; and you are to mind which are opposite to each other (for that is very material) as ♈ is opposite to ♎, ♈ to ♊, &c. for it will shew you the different times and seasons of the year, &c. very readily, when you come to perform any operation.

Tyro. I will observe what you say; but please to tell me the signification of their names.

Philo. It is of no great service; however, here they follow: Aries ♈, or the Ram; Taurus ♉ the Bull; Gemini ♊ the Twins; Cancer ♋ the Crab; Leo ♌ the Lion; Virgo ♍ the Virgin; Libra ♎ the Balance; Scorpio ♏ the Scorpion; Sagittarius ♐ the Archer; Capricornus ♑ the Goat; Aquarius ♒ the Water-bearer; and Pisces ♓ the Fishes.

Tyro. Pray, Sir, inform me why the ancient astronomers affixed such images as the Ram, the Bull, &c. to the 12 Signs of the Zodiac.

Philo. It is not easy to give a positive answer to your question; but there is great reason to suppose that they were placed as Hieroglyphics of the seasons of the year, alluding to the annual course of the Sun.

Thus, Aries, Taurus, and Gemini, represent March, April, and May, the spring quarter of the year, when Lambs, Calves, and Goats (the latter generally bringing forth twin kids) are produced.

Cancer, the Crab, which creeps both ways, represents the increase and decrease of the Sun's declination, to and from the summer solstice, in June.

Leo, the Lion, intimates the raging heat of the sun in July, which the ancients compared to the furious nature of that fierce animal.

Virgo, the Virgin, with a spike or ear of corn in her hand, properly represents August, when the harvest of the earth is ripe.

Libra,

Libra, the Balance, is displayed in September, to intimate that the days and nights, at the autumnal Equinox, are equal in all parts of the globe.

Scorpio, the Scorpion, a noxious animal, is placed as the Hieroglyphic of October; because, at that season, diseases of various kinds too often rage.

Sagittarius, the Archer, marks November, as the proper time for hunting.

Capricornus, the Goat, by its climbing up the rocks, is placed as an emblem of December, when the sun, at the winter solstice, begins to ascend again towards the Equinoctial.

Aquarius, the Water-bearer, with his urn, represents January, when rains are frequent.

Pisces, the Fishes, are emblems of the fishing season, which began in the Nile during the month of February.

N. B. The Ecliptic cuts, or intersects the Equator, or Equinoctial, at the two points, or signs, Aries γ and Libra ♎ , viz. on the 21st of March, and the 22d of September, N. S. on which days the sun is in the Equator, and has no declination, either N. or S. and the days and nights are then equal to all the inhabitants on the globe, as you will plainly see by and by.

3. *Of the* BRAZEN MERIDIAN.

Tyro. What is the Brazen Meridian?

Philo. The Brazen Meridian is another great circle, which divides the Globe into two equal parts, called the Eastern and Western hemispheres, whose poles are in the East and West

points of the Horizon. It is represented by a thick brass hoop, which surrounds the Globe, from N. to S. and divides the Equator into 2 equal parts, viz. the E. and the W. and is that on which the Globe itself is hung, or turns round upon its axis, the extremities of which are called the poles.

Tyro. How is the Brazen Meridian marked, or divided?

Philo. Like the Equator and Ecliptic, into 360 degrees; but with this difference, it is divided into 4 nineties.

Tyro. In what manner, pray?

Philo. From the Equator towards the N. and S. Pole, the Meridian is marked with a cypher over the Equator, thus (0); and on each side, with 10, 20, 30, 40, 50, 60, 70, 80, and 90, which ends in each pole. Then again, from each pole to the Equator on the other half of the Meridian, is marked 10, 20, 30, 40, &c. to 90, which ends in the Equator.

Tyro. Then I plainly perceive by this, that as many degrees as one pole is elevated or raised, so many degrees will the contrary pole be depressed.

Philo. Your notion is very just.

Tyro. But pray, what is the principal use of this circle?

Philo. The Brazen Meridian shews you the latitude of places, and their difference of latitude, either N. or S. from the Equator: for the latitude of a place is the same as the elevation of the pole above the Horizon. That is, whatever figure, or number, the Horizon cuts the Meridian

ridian in, so many degrees is the pole elevated, which is the latitude, as you will more plainly see, when we come to speak of latitude and longitude.

4. *Of the HORIZON.*

Tyro. What is the Horizon?

Philo. The Horizon is that great circle which divides the heavens and earth into two equal parts, one called the upper, and the other the lower Hemisphere, whose poles are in the Zenith and Nadir. There are two sorts, the one called the sensible or apparent, the other the rational or real Horizon.

Tyro. What is the sensible Horizon?

Philo. The sensible Horizon is that which divides the visible part of the heavens from the invisible; and is that great circle which we see all round us (standing upon any hill, or at sea) just in the points where the heavens and earth seem to meet, or to be joined together.

Tyro. What is the rational Horizon?

Philo. The rational Horizon, is that which passes through the centre of the earth, and divides it (as was said before) into the upper and lower Hemisphere.

 This rational Horizon is represented by that broad wooden circle, lying with its face upwards, having two notches cut in it, one in the N. and the other in the S. part, in which the Brazen Meridian is slipt, or moved up or down, at pleasure: the poles of the Horizon are the Zenith and Nadir.

Tyro. Please to give me a further description of the Horizon?

Philo. If you use Senex's Globes, as improved by Martin, the Horizon plate will contain on its surface five circles.

1. The circle that is next the globe shews the Azimuth, &c.

2. The second circle is that of Amplitude, &c.

3. The third circle contains the 32 points of the Mariner's compass.

4. The fourth is that of the Months and Days throughout the Year.

5. The fifth circle is the Ecliptic, and contains the marks, names, and figures of the 12 Signs of the Zodiac.*

Tyro. Sir, I think you kindly. Pray, tell me now the use of the Horizon.

Philo. The Horizon shews the rising and setting of the sun, length of days and nights; also the rising and setting of the stars in any latitude; together with the Azimuth, Amplitude, Almanther, &c. of the sun, or any star, and the point they rise or set upon, &c.

5. Of the COLURES.

Tyro. Pray, what are the Colures?

Philo. The Colures are two great circles, cutting the Equator at right angles, and passing through the poles of the world.

The Solstitial Colure is that great circle which

* The modern globes have only four circles on the Horizon; that next the globe serving for both the Azimuth and Amplitude. The second contains the points of the compass. The third is the Ecliptic. The fourth the months and days; and, on some globes, the Saints' Days.

passes through Cancer and Capricorn, shewing Winter and Summer.

The Equinoctial Colure passes through Aries and Libra, and shews the Spring and Autumn.

And, now, having given you a full description of the great circles; I propose to describe the lesser, and shew you more of the nature of the globe, and the appendants belonging to it.

DIALOGUE VI.

Concerning the lesser Circles of the Sphere, commonly called Parallel Circles.

SECT. I.

Tyro. **W**HAT do you mean by the lesser, or parallel circles.

Philo. All such circles as do not divide, or cut the globe into two equal parts, but that cut off any segment, or part, less than the half, are lesser circles?

Tyro. Why are they called parallel circles?

Philo. Because they are parallel every where to the Equator.

Tyro. Pray tell me the names of the lesser circles.

Philo. They are the Tropics and Polar circles.

I. *Of the Tropics.*

Tyro. Pray, which are the Tropic Circles?

Philo. Look for the sign Cancer on the globe, and you will find a circle drawn with a double, or dotted, line from thence round the globe, parallel

to the Equator, which is called the Northern Tropic, or Tropic of Cancer, being $23\frac{1}{2}$ degrees from the Equator northward, shewing the Sun's greatest northern declination. Then looking for the sign Capricorn, you will find the same sort of circle, which is called the *Southern Tropic*, being also $23\frac{1}{2}$ degrees from the Equator, and shewing the sun's greatest southern declination, or departure from the Equinoctial.

2. Of the POLAR CIRCLES.

Tyro. Which are the Polar Circles?

Philo. They are two small circles, lying near the poles (viz. $23\frac{1}{2}$ degrees distant from them) drawn also with double lines: that on the N. is called the Arctic circle, and that on the S. the Antarctic circle. They are called Polar Circles, from their being described by the revolution of the Poles of the Ecliptic, round the poles of the world, at 23 degrees, 30 minutes, distance from them, by a retrograde motion, in 25920 years; occasioned by the precession of the Equinoxes, 50 seconds every year.

Tyro. Pray, what is their use, or what do we learn from them?

Philo. All those inhabitants that live under these lines have their longest day just 24 hours long, and their longest night the same (save the benefit of twilight, which is but trifling.) If you go further towards the poles, their days are 2, 3, and 4 days, or 2, 3, 4, or 6 months long, as you will find demonstrated in the problems.

Tyro.

Tyro. Surprising! I long to see those places, having heard of such things, but always looked upon them as idle tales.

Philo. You may depend upon the truth of it, and will soon see the reason. But, now, we will shew you the Appendants belonging to the globes.

S E C T. II.

Of the Appendants belonging to the Globes.

Tyro. **W**HAT do you mean by Appendants?

Philo. Appendants are in some respects the same as Appurtenances, being such necessary things, both moveable and immoveable, as belong to globes; the principal or chief of which are as follow:

I. *Of the Hour Circle, and Index.*

Tyro. Pray what is the Hour Circle, and its use?

Philo. The Hour Circle, called also the Hourly Circle, or Dial-Plate, is a small circle of brass, divided into 24 hours; the upper 12 represents noon, and the lower 12 midnight. It is screwed on the meridian round the N. pole, and on the pole itself is placed the Index, or Hand, which turns round with the globe.*

* For the greater conveniency of elevating the South Pole, and viewing the New Discoveries, the modern globes have the Hour Circle placed on the surface of the globe, under the brass meridian, and not on the meridian, as above described

Its use is to tell the time of the rising and setting of the sun, or stars, in any latitude; and what o'clock it is in any part of the world, &c.

2. *Of the Quadrant of Altitude.*

Tyro. Pray, what is the Quadrant of Altitude?

Philo. This is a thin piece of pliable brass, divided into 90 degrees, answering to the degrees of the equator, beginning at the lower end with (0) and proceeding to 10, 20, 30, &c. till we come to 90. At which figure it has a nut, which slips upon the meridian at pleasure, and is fastened thereto by a screw.

Tyro. Pray, what is the chief use of this Appendant?

Philo. Its use is to tell the height of the sun, or stars, at any hour, and when they are due E. or W. Also the distance of the stars from one another, and the distance of one place from another on the terrestrial globe, &c. &c. &c.

3. *Of the Semi-circle.*

Tyro. What is the Semi-circle of position?

Philo. It is a thin piece of brass, divided into 180 degrees, answering to one half of the Equator. It may be called a double quadrant of Altitude, but is used only in some particular problems, the Quadrant, or Horizon, in general, supplying its place.

4. *Of the Nautical Box, or Mariner's Compass.*

Tyro. What is the Nautical Box, and its use?

Philo.

Philo. This is an instrument used in navigation, having the 32 points of the wind marked, or drawn, on a Card, and a needle being touched with the load-stone points always northward. This Compass is sometimes fixed in the bottom of the frame, under the centre of the globe, for the purpose of placing the globe in a right position; viz. so as for the four cardinal points of the Horizon to be directed towards their corresponding points in the heavens.

S E C T. III.

Concerning the different Names of the Sphere, according to its different Position, or Situation.

Tyro. **W**HAT do you mean by the Sphere's having different names, according to its position? I do not understand you.

Philo. Observe then. There are 3 sorts of Spheres; viz. a Parallel, a Right, and an Oblique Sphere.

1. A Parallel Sphere.

1. A Parallel Sphere is so called, because under it the Equator coincides, or is parallel with the Horizon. 2. The Poles are in the Zenith and Nadir; that is, one pole is right up, and the other right underneath.

Properties of this Sphere.

The inhabitants of this Sphere are those that live under the poles, who have but one day
and

and one night in the year. This day continues six months, while the sun passes through six of the signs of the Zodiac; and the night six months, while he passes through the other six. The day to those who live under the North pole begins when the sun enters Aries, and continues till he reaches Libra; when night commences, and continues the other six months. Those who live under the South pole experience the direct contrary, it being day with them when it is night with the former, and *vice versa*. But both enjoy a long continuance of twilight, both after the sun has departed, and before he appears.

Tyro. Pray, Sir, what do the polar inhabitants (if there be any) observe with respect to the sun, moon, and stars?

Philo. 1. They see the sun for half the year, moving continually round above the Horizon, in a spiral line, the first round skimming the skirts of the Horizon; the second higher, and so on, till by 90 revolutions he has reached the Tropic, his utmost declination; after which, by 90 more revolutions, he again reaches the Horizon, and then their long winter's night begins.

2. They see the moon during their summer's day only as a white cloud in the sky; and in the winter, during her second and third quarters, she moves as the sun did, round and round for a continuance of several days without setting; being a fortnight above, and a fortnight under the Horizon.

3. They can only see that hemisphere of stars between the Pole and the Equator, the fewest
seen

seen by any of the inhabitants of the earth. During half a year they see none, (the stars being swallowed up in the superior light of the sun) and their view of them is but short in the winter's night, by reason of the long twilight. To them the stars never set, but move in circles parallel to the Horizon, keeping always the same altitude. The planets are half their time above, and half below the Horizon.

2. *A Right Sphere.*

1. A right Sphere is so called, because under it the Equator cuts the Horizon at right angles.
2. The poles will lie, or be in the Horizon.
3. The Equator will be in the Zenith and Nadir.

Properties of this Sphere.

The inhabitants of this Sphere are those who live under the Equinoctial Line, or Equator, and have their days and nights always equal; viz. 12 hours each; because not only the Equator, but also all the Parallels are cut into two equal parts by the Horizon. And therefore as the sun's diurnal arches are equal to the nocturnal, each day must be equal to the night, viz. 12 hours each.

Tyro. How do the sun, moon, and stars appear to the inhabitants under the Equinoctial.

Philo. The sun rises and sets nearly perpendicular, nor can he have more than 23 degrees, 30 minutes, either North or South amplitude.

He

He comes to the meridian with the same degree of the Equator with which he rose; and hence there can be no ascensional difference. He is half a year on one side of their Zenith, and as much on the other; passing over their Zenith twice a year, *viz.* at the Equinoxes.

With regard to the moon, there is nothing uncommon, or different in her appearances, from those in an oblique sphere, except her rising and setting nearly in a perpendicular direction like the sun.

But here is a glorious display of all the stars in the heavens, from pole to pole; all of them rising and setting perpendicular to the Horizon, except the pole stars, which lying in the Horizon, are rendered invisible by the denseness of the atmosphere. The twilight is shorter in this sphere than in any other, for the same reason that it is shortest with us at the Equinox.

3. *An Oblique Sphere.*

An Oblique Sphere is that position of the globe, which all the inhabitants of the earth, excepting those under the Poles and Equinoctial, enjoy; and is so called, because under it the Equator cuts the Horizon obliquely.

Properties of this Sphere.

1. The pole is elevated to any degree less than 90, the axis of the earth always making an acute angle with the Horizon.

2. All the parallels to the Equator cut the Horizon obliquely, making the diurnal greater
or

or less than the nocturnal arches; and consequently producing an inequality in the days and nights, which are never equal but when the sun is in Aries and Libra, which happens in March and September, when he moves in the Equator, making equal days and nights to all the inhabitants of the earth, except those under the poles.

3. The inhabitants of this Sphere, who live without the tropics, never have the sun in their Zenith; though they may sometimes see the moon there, on account of her latitude: but under the tropics the sun is vertical once, and to every place between the tropics and the Equator twice every year.

4. The stars rise and set obliquely in this position; and the nearer the observer is situated to the Equator, the greater number of them will be visible. The length of the twilight is longer or shorter in this position, according as the latitude is greater or less.

5. The moon, when at full, being always in an opposite sign to the sun, must, in summer, be in the winter signs, and consequently make a short, low course. But in winter she will move through the summer signs, making a high, long circuit; which is of great use in that dreary season.

S E C T. IV.

Of the different Names of the Inhabitants of the Globe, with respect to their Situation.

Tyro. **Y**OU have already explained to me the three different positions of the Sphere; pray, what do you mean by the names of the several inhabitants?

Philo. Without any regard to the different positions of the Sphere, these inhabitants have different names according to the several meridians and parallels of latitude they lie under.

Tyro. Please to tell me their different names.

Philo. There are 6 different kinds of inhabitants; 1. Antœci. 2. Periœci. 3. Antipodes. 4. Amphiscii. 5. Periscii. And 6. Heteroscii.

1. *Of the ANTOECI.*

The Antœci, or Antœcians, are those inhabitants that have the same longitude with us, that is, lie under the same meridian; but they are as far to the S. of the Equator, as we are to the N.

Their Properties.

1. Their hour is the same as ours, it being noon, &c. with both at the same time. 2. Their days are equal to our nights, and *vice versa*. And 3. Their summer is our winter.

2. *Of the PERIOECI.*

The Periœcians are those that lie under the same parallel of latitude with us, on the same
side

side of the Equator, only are distant 180 degrees of longitude ; viz. a semi-circle.

Their Properties.

1. They have contrary hours ; it being noon with them when it is midnight with us. 2. Their days and nights are of the same length as ours. 3. Their season, or time of the year, is also the same as with us.

3. *Of the ANTIPODES.*

The Antipodes are such inhabitants as have the same latitude S. as we have N. but differ 180 degrees in longitude. That is, they and we have opposite parallels, and opposite meridians.

Their Properties.

1. Their hour is directly the reverse of ours, it being noon with them, when it is midnight with us. 2. Their longest day is our shortest day, and their longest night our shortest night. And 3. The four seasons are contrary, their summer being our winter, &c. &c.

Tyro. It is wonderful indeed ! I have often heard, it is true, that there are such persons as walk with their feet to our feet (that is, go with their heads downwards in respect of us :) pray are not the Antipodes this sort of people?

Philo. They are, and however strange it may seem, it is certainly true ; and this you will easily see, when you come to the problems, if you will have but a little patience.

Tyro.

Tyro. Sir, I am obliged to you, and will be content till then. Please now to tell me concerning the other three kinds of inhabitants?

Philo. They have their names from the different positions of their shadows.

4. *Of the AMPHISCII.*

They are so called, because their shadows are cast different ways, at noon day, at different times of the year; that is, their shadow sometimes points to the North, and sometimes to the South. Therefore, it is easy to perceive that these people live in the Torrid Zone, that is, between the Tropics.

5. *Of the PERISCII.*

These are so called because their shadows go quite round them. Such are the inhabitants that dwell within the Polar Circles, that is, from $66\frac{1}{2}$ degrees of latitude to 90, where the sun for part of the year never setting, but moving round the Horizon, makes the shadows of the people likewise move around them.

6. *Of the HETEROSII.*

They are so called, as having their shadow cast but one way, that is, either always towards the N. or always towards the S.

These are such as live in the Temperate Zones; that is, between the Tropics and the Polar Circles. Those in the South Temperate Zone have their shadows cast always southward;
and

and those in the North Temperate Zone have their shadows always cast northward, as in England, France, Spain, and most other parts of Europe.

S E C T. V.

Of the ZONES, and CLIMATES.

I. *Of the ZONES.*

Tyro. **W**HAT do you mean by the Zones?
Philo. A Zone, or Girdle, is a tract, or space, that furrounds the surface of the earth, as a Belt, or Girdle, does the body.

Tyro. How many Zones are there?

Philo. Five; viz. One Torrid Zone, two Temperate Zones, and two Frigid Zones.

Tyro. You gave me an account of their different situations in the last section; be pleased, now, to tell me their extent, that I may have a better idea of the division of the globe.

Philo. You remember that I told you from the Equator to either Pole is 90 degrees; therefore, from the N. to the S. Pole is 180 degrees. Observe then,

1. The Torrid Zone extends from the Equator to the Tropic of Cancer northward, and to the Tropic of Capricorn southward, $23\frac{1}{2}$ degrees each way, viz. 47 degrees in all.

2. The Temperate Zones extend themselves from the two Tropics to the Polar Circles on both sides of the Equator; each of them containing 43 degrees, or 86 degrees together.

3. The

3. The Frigid Zones extend from the Polar Circles to the Poles, being each $23\frac{1}{2}$ degrees, or 47 together; for $23\frac{1}{2}$, 43, and $23\frac{1}{2}$, make 90 degrees; the distance from the Equator to either Pole. Or rather thus, the Torrid Zone contains 47 degrees, the Temperate Zones 86, and the Frigid 47, in all 180 degrees.

Tyro. Sir, I thank you for this explanation; it is very easy to be understood: please, now, to tell me what you mean by the climates?

2. *Of the CLIMATES.*

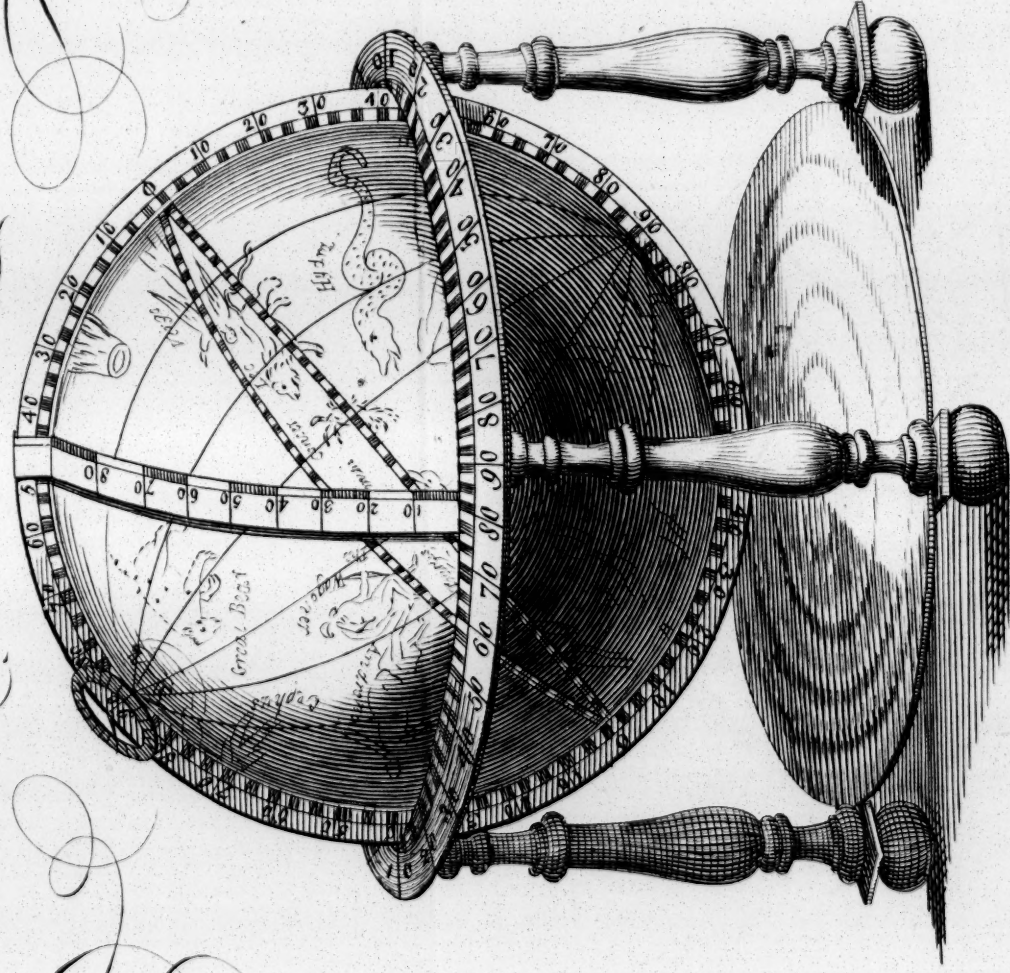
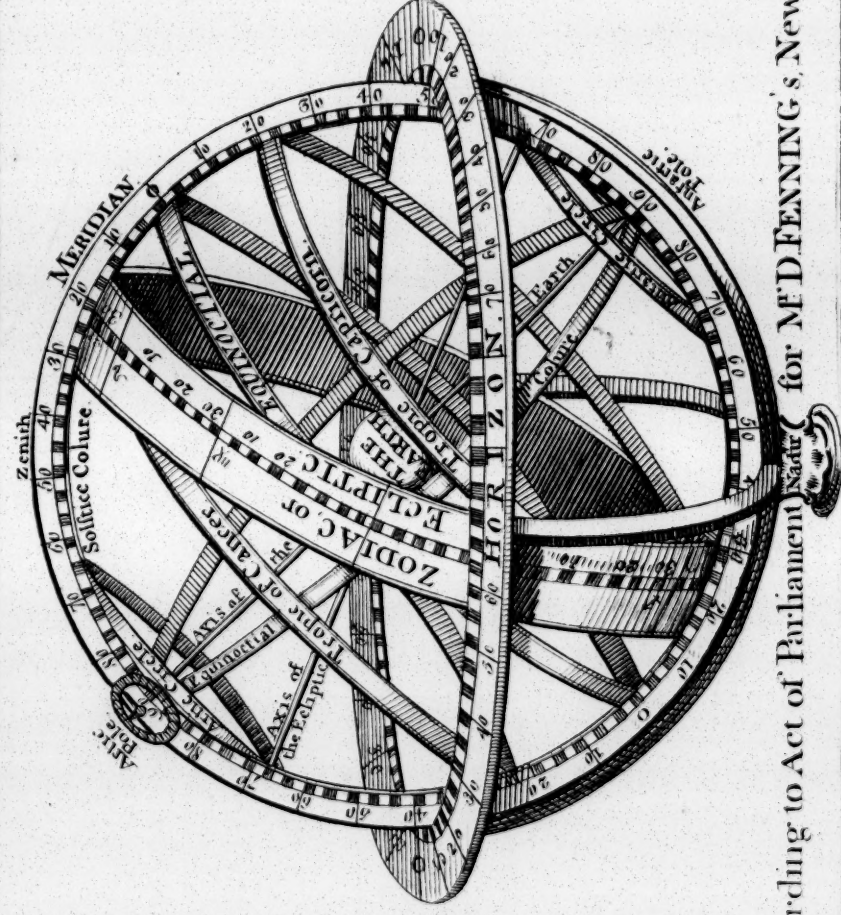
Philo. Climates are tracts, or circles upon the surface of the globe, parallel to the Equator, of such a certain breadth, that the artificial day in each (viz. from sun-rise to sun-set) exceeds that in the next climate nearer the Equator by half an hour, till you come to the Polar Circles, and then, indeed, the day encreases in each climate by one entire month.

Tyro. How many Climates* are there that differ by the half hour, and how many by the entire month?

Philo. There are 60 Climates in all, viz. 30 on each side of the Equator, called accordingly North and South: of these 60, 48 extend from the Equator to the Polar Circles, and each differs by half an hour. And the remaining 12 are contained between the Polar Circles and the Poles, each differing one entire month from the other.

* Great Britain extends from the middle of the 9th to about the middle of the 13th North Climate; viz. about four climates.

THE
CELESTIAL GLOBE AND
SPHERE.

*Powell Sculpt.*

Engrav'd According to Act of Parliament for M^r D^r FENNING's, New Use of the Globes

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D I A L O G U E VII.

*An Explanation of the most common Terms used in
Geography and Astronomy.*

S E C T. I.

Tyro. **Y**OU have, Sir, given me a very clear and satisfactory account of the nature and properties of the globe: I will now trouble you to explain the terms to me; for what can I do, till I know the signification of such words as are used in the science.

Philo. It is very true, and I will explain them as well as I am able; and, pray, be careful to get them by heart, though not just in the very words I use, yet so as to know the meaning of them, and the practical part will then easily follow; for the want of this is the chief reason that most learners are so deficient in what they undertake.

Tyro. You may depend upon my care.

Philo. Very well; I am satisfied, in hopes of your keeping your promise.

Explanation of the Terms.

1. Zenith, is that point of the heavens that is right over our head.

2. Nadir, is that point right under our feet, being directly, or diametrically, opposite to the Zenith.

3. Zenith Distance, is the number of degrees that the sun, or any star, wants of 90 degrees, when they are upon the meridian, or greatest height.

4. Alti-

4. Altitude is height. Meridian Altitude is the greatest Altitude, or height, at 12 o'clock.

5. Declination, is the distance of the sun, or any star, from the Equator or Equinoctial, counted on the Brazen Meridian in degrees, and is called North, or South, according to the side of the Equinoctial on which the declination is.

6. Right Ascension, is an Arch of the Equinoctial, contained between the sign Aries γ , and the degree of the Equinoctial that is cut by the Brazen Meridian, when the sun, or star, is brought to the Meridian.

7. Oblique Ascension, is that Arch of the Equinoctial contained between the sign γ , and the degree of the Equinoctial, which is cut by the Horizon at the rising of the sun, or star.

8. Oblique Descension, is just the reverse, being that Arch of the Equinoctial, contained between the sign Aries and the degree of the Equinoctial, that is cut by the Horizon, at the setting of the sun, or star.

9. Ascensional Difference, is the difference of degrees, between the right and oblique Ascension, which converted into time, by allowing 15 degrees for every hour, shews how much the sun, or star, rises, or sets, before or after six. That is, subtract the less from the greater number, and the remainder will give the ascensional difference.

10. Amplitude, is an Arch of the Horizon, contained between the true E. or W. point, and that degree of the Horizon where the sun or stars

stars rise or set, and is called North, or South Amplitude, accordingly.

11. Azimuth, is in effect the same as Amplitude, save only with this difference; that whereas Amplitude is only at rising and setting, Azimuth shews the distance from the E. and W. points, at any time, when the sun, or stars, are above the Horizon.*

12. Almacanters are circles of Altitude passing through every degree and minute of the Meridian, parallel to the Horizon.

13. Elevation of the pole, is the same as Latitude. There are three sorts, viz.

1. Latitude of a place, is its distance from the Equator, either North or South, numbered in Degrees on the Brazen Meridian: or, in other words, it is the Elevation of the Pole above the Horizon.

2. Latitude (in Navigation) is the distance of a ship from the Equinoctial, counted on the Meridian. So that if a ship sails towards the Equinoctial, she is said to depress the pole; and, if she sails from the Equinoctial, she is said to raise the pole.

* *Note, Azimuth is not expressed alike in all authors. Some call it always North or South Azimuth, and reckon the Azimuth from these two points eastward, or westward. Others reckon it from the E. and W. points, either northward or southward, which, I think, is best, these being the two points that Azimuth is nearest to in our, or any lesser latitude, at any hour: however, it matters not which way you reckon, if you mind this one rule; suppose I say, the sun has 60 degrees Azimuth from the N. eastward, it is the same as if I say he has 30 degrees Azimuth from the E. northward. See PROBLEM XXI.*

3. Latitude of a star, is its distance from the Ecliptic, being an arch of a circle of longitude, reckoned from the Ecliptic towards its pole either N. or S.

14. Longitude is also of three sorts, viz.

1. Longitude of a place, is an Arch of the Equator, intercepted between the first Meridian on the Equator and the Meridian of the place.*

2. Longitude of a star, is an Arch of the Ecliptic, counted from the beginning of Aries, to the place where the star's circle of longitude crosses the Ecliptic; so that it may be said to be the star's place in the Ecliptic, counted from the point Aries, which cannot exceed 180 degrees from the Equinoctial point.

3. Longitude (in Navigation) is an Arch of the Equator, contained between the first Meridian and the Meridian the ship is on.

* *Note*, The *Longitude* of places differs according as you fix your first *Meridian*. Thus, upon some globes, *London* is 23 degrees E. longitude, on others 20, &c. and on all *Senex's* globes 18 degrees E. longitude from the first *Meridian*. For some place their first *Meridian* at *Gratioso*, others at *Teneriff*, and *Senex* at *Ferro*. But this matters not at all; for when you know the difference (as you will soon learn that by practice) you will know how to work by either, and have the answers accordingly.

N. B. In reckoning longitude from *London*, you will find at 18 degrees from *Aries* eastward on *Senex's* globe, a cypher (0) on the lower part of the *Equator*, under the meridian of *London*, and there begins the longitude from *London*, viz. Longitude extends 180 degrees eastward, numbered by 10, 20, 30, &c. No longitude exceeds 180; for 181 E. is more properly 179 W. longitude.

Tyro.

Tyro. I humbly thank you, Sir, for these definitions, which when well understood, must render the use of the globes very easy.

Philo. Indeed, my dear pupil, there can be nothing hard in the practical part, when once you have a tolerable notion of what I have shewn you.

But, because I would have you understand yet more, I have inserted the following tables (which are not to be found in any other small treatise I ever saw) that you may not be at a loss, when you work any curious problems, but may be able to refer to them, both for instruction and confirmation.

S E C T. II.

Containing four TABLES that are not only useful, but indispensably necessary to the right Understanding the Use of the Globes, viz.

T A B L E I.

A TABLE of the Latitude and Longitude of the most remarkable Places, from the latest Observations.

Places.	Latitude.		Longitude.	
Adrianople, Turkey, in Europe	42	00'N.	26	30'E.
Aix la Chapelle, in Westphalia	50	45'N.	5	50'E.
Aleppo, Syria, in Asia	35	45'N.	37	25'E.
Alexandria, Egypt, in Africa	31	11'N.	30	21'E.
Amsterdam, in Holland (and capital)	52	23'N.	4	51'E.
Archangel, in Russia	64	34'N.	39	00'E.
Babylon, in Chaldea (called Bagdad)	33	00'N.	42	52'E.
Barbadoes, in the West Indies	13	00'N.	59	50'W.
Batavia, East Indies	6	10'S.	106	57'E.
Berlin, Upper Saxony, in Germany	52	33'N.	13	30'E.
Bologne, Picardy, in France	50	44'N.	1	42'E.
Boston, New England, America	42	25'N.	70	32'W.
Botany Bay	33	50'S.	151	00'E.
Bristol, in England	51	28'N.	2	40'W.
Cadiz, Andalusia, in Spain	36	31'N.	6	6'W.
Cairo, Egypt, in Africa	30	03'N.	31	31'E.
Calcutta, Bengal, in the East Indies	22	34'N.	88	34'E.
Candia, in the Island of Candia	35	19'N.	25	25'E.
Canterbury, in Kent	51	16'N.	1	15'E.
Canton in China	23	08'N.	113	8'E.
Candy, in the Island of Ceylon	7	54'N.	79	00'E.

Places.	Latitude.	Longitude.
Cape of Good Hope, Africa	34° 29'S.	18° 30'E.
Charles-Town (Carolina) N. America - - -	32° 45'N.	79° 12'W.
Cochin, East Indies - - -	9° 50'N.	76° 05'E.
Constantinople, Romania, in Turkey (and capital)	41° 00'N.	28° 58'E.
Copenhagen, Zeland, in Den- mark (and capital) - - -	55° 41'N.	12° 41'E.
Corinth, Morea, in Turkey	37° 30'N.	23° 00'E.
Cork, Ireland - - -	51° 54'N.	8° 23'W.
Cracow, Poland - - -	50° 10'N.	19° 55'E.
Cremona, Milan, in Italy -	45° 10'N.	10° 32'E.
Cyprus Island, in the Levant	35° 00'N.	34° 00'E.
Dublin, capital of Ireland -	53° 21'N.	6° 01'W.
Dunkirk, Flanders - - -	51° 02'N.	2° 27'E.
Edinburgh, capital of Scotland	55° 58'N.	3° 07'W.
Ephesus, Natolia, in Asia -	38° 00'N.	27° 35'E.
Florence, Italy - - -	43° 46'N.	11° 08'E.
Frankfort, on the Main, in Ger- many - - -	49° 55'N.	8° 40'E.
Gibraltar, Andalusia, in Spain	36° 06'N.	5° 17'W.
Glasgow, in Scotland -	55° 52'N.	4° 10'W.
Hague, in Holland - - -	52° 04'N.	4° 23'E.
Hanover, Saxony, in Germany	52° 32'N.	9° 35'E.
Jerusalem, Palestine, in Asia -	31° 55'N.	35° 25'E.
Koningsburgh, Prussia in Po- land - - -	54° 43'N.	21° 35'E.
Lima, in Peru, in S. America	12° 01'S.	76° 45'W.
Lisbon, capital of Portugal	38° 42'N.	9° 04'W.
London, capital, or metropolis, of England - - -	51° 32'N.	0° 00'
Madras, Coromandel, East-Indies	13° 05'N.	80° 33'E.
Madrid, New Castile, in Spain, (and capital) - - -	40° 25'N.	3° 20'W.
E 3		

Places.	Latitude.		Longitude.	
	°	'	°	'
Malta, near Sicily, in the Mediterranean	-	-	35	54N. 14 34E.
Mexico, N. America	-	-	19	54N. 100 00W.
Moscow, Russia	-	-	55	45N. 37 51E.
Nankin, or Nanquin, in China	32	07N.	118	35E.
Naples, in Italy	-	-	40	51N. 14 19E.
St. Omer's, French Netherlands	50	45N.	2	20E.
Panama, S. America	-	-	8	48N. 80 14W.
Paris, capital of France,	-	-	48	50N. 2 25E.
Pekin, in China	-	-	39	54N. 116 30E.
Petersburgh, the capital of Russia	60	00N.	30	25E.
Philadelphia, N. America	-	-	39	57N. 75 08W.
Port Royal, Jamaica	-	-	18	00N. 77 00W.
Prague, capital of Bohemia, in Germany	-	-	50	05N. 14 50E.
Presburgh, in Hungary	-	-	48	22N. 17 30E.
Quebec, in Canada, N. America	46	55N.	69	48W.
Rhodes Island, Archipelago	-	-	36	00N. 28 00E.
Rome, capital of Italy	-	-	41	54N. 12 34E.
Siam, in the East Indies	-	-	14	18N. 100 55E.
Spires, Upper Rhine, Germany	49	00N.	8	10E.
Stockholm, capital of Sweden	59	20N.	18	08E.
Syracuse, Sicily	-	-	37	04N. 15 20E.
Tangier, Barbary, in Africa	35	55N.	5	45W.
Thyatira, Natolia, Asia	-	-	38	28N. 28 32E.
Tripoli, Barbary, Africa	-	-	32	54N. 13 10E.
Tunis, ditto	-	-	36	47N. 10 16E.
Venice, Italy	-	-	45	26N. 12 18E.
Vienna, Germany (capital)	48	13N.	16	28E.
Warsaw, the capital of Poland	52	14N.	21	06E.
York, in England	-	-	54	00N. 1 02W.
York (New) N. America	40	43N.	74	04W.

Greenwich Observatory, Kent, England, lat. $51^{\circ} 28' 40''$ N.
long. $0^{\circ} 5' 37''$ E. of St. Paul's, London.

TABLE

T A B L E II.

S H E W I N G

The Number of Miles contained in a Degree of Longitude,
at every Degree of Latitude, from the Equator.

Degrees of Latitude.	Miles.	100th Parts of a Mile.	Degrees of Latitude.	Miles.	100th Parts of a Mile.	Degrees of Latitude.	Miles.	100th Parts of a Mile.
1	59	92	31	51	43	61	29	09
2	59	96	32	50	88	62	28	17
3	59	92	33	50	32	63	27	24
4	59	85	34	49	74	64	26	30
5	59	77	35	49	15	65	25	36
6	59	67	36	48	54	66	24	40
7	59	56	37	47	92	67	23	45
8	59	42	38	47	28	68	22	48
9	59	26	39	46	63	69	21	50
10	59	09	40	45	95	70	20	52
11	58	89	41	45	28	71	19	54
12	58	69	42	44	59	72	18	54
13	58	46	43	43	88	73	17	54
14	58	22	44	43	16	74	16	54
15	57	95	45	42	43	75	15	53
16	57	67	46	41	68	76	14	52
17	57	38	47	40	92	77	13	50
18	57	06	48	40	15	78	12	48
19	56	73	49	39	36	79	11	45
20	56	38	50	38	57	80	10	42
21	56	02	51	37	76	81	09	38
22	55	63	52	36	94	82	08	35
23	55	23	53	36	11	83	07	31
24	54	81	54	35	27	84	06	27
25	54	38	55	34	41	85	05	23
26	53	93	56	33	55	86	04	18
27	53	46	57	32	68	87	03	14
28	52	97	58	31	80	88	02	09
29	52	48	59	30	90	89	01	05
30	51	96	60	30	00	90	00	00

T A B L E III.

OF THE CLIMATES.

From the Equator to the Polar Circles.			From the Equator to the Polar Circles.		
Climates.	Ends in Latitude of	Where the longest Day is	Climates.	Ends in Latitude of	Where the longest Day is
	Deg. Min.	H. Min.		Deg. Min.	H. Min.
1	8 34	12 30	13	59 58	18 30
2	16 42	13	14	61 18	19
3	24 10	13 30	15	62 25	19 30
4	30 46	14	16	63 22	20
5	36 28	14 30	17	64 8	20 30
6	41 22	15	18	64 49	21
7	45 29	15 30	19	65 21	21 30
8	49 1	16	20	65 47	22
9	51 58	16 30	21	66 6	22 30
10	54 27	17	22	66 20	23
11	56 37	17 30	23	66 28	23 30
12	58 29	18	24	66 31	24
From the Polar Circles to the Poles.			From the Polar Circles to the Poles.		
1	67 21	1 Months	4	78 30	4 Months
2	69 48	2	5	84 5	5
3	73 37	3	6	90 0	6

TABLE

A TABLE of the right Ascension, Declination, Latitude, and Longitude of some of the most eminent fixed Stars, taken from Senex's Celestial Globe, 1754, for the Use of the Learner; and now rectified to the Beginning of the Year 1792, with Additions.

Names and Constellations.	R.	A.	Declin.	Lat.	Long.
Aldebaran, in Taurus*	66	00	16	5	6
Algenib, in Pegafus*	-	-	14	12	6
Alloth, in Urfa Major	191	12	57	54	5
Alcair, or Atair, in Aquila*	295	9	8	29	28
Albiero, in Cygnus	290	35	27	49	28
Aridef, in ditto	308	35	44	59	2
Achernar, in Eridanus	22	29	58	59	12
Alfeta, in Corona	231	29	27	44	9
Arcturus, in Bootes	211	34	20	30	21
Arietis, in Aries*	-	52	22	9	4
Asengue, in Lyra	277	28	38	61	12

Names and Constellations.	R.	A.	Declin.	Lat.	Long.
Bellatrix, in Orion	78	30	6° 9' N.	16° 53' S.	18° 2'
Betelgeuze, in ditto	85	59	7° 21' N.	16° 45' S.	25° 50'
Benenaëz, in Urfa Major	204	50	50° 21' N.	54° 25' N.	23° 51'
Canobus, or Canopus, in Argo Navis	94	56	52° 35' S.	75° 51' S.	12° 11'
Castor, in Gemini	110	19	32° 20' N.	10° 4' N.	17° 21'
Castor's Brother, Pollux, ditto*	113	8	28° 31' N.	6° 39' N.	21° 21'
Capella, in Auriga	75	20	45° 46' N.	22° 52' N.	18° 57'
Cor Hydræ, Hydra's Heart	139	20	7° 46' S.	22° 24' S.	24° 25'
Cor Scorpionis, Scorpio's Heart*	244	10	25° 57' S.	4° 31' S.	6° 51'
Cor Leonis, called Regulus*	149	19	12° 59' N.	0° 27' N.	26° 57'
Deneb, in Leo Major	174	37	15° 44' N.	12° 17' N.	18° 45'
Enif, in Pegasus	323	29	8° 56' N.	22° 8' N.	29° 1'
Fomalhaut, in Southern Fish*	341	32	30° 43' S.	21° 4' S.	0° 54'
Gauby, in Libra's South Scale	219	52	15° 10' S.	0° 22' N.	12° 11'
Marhal, or Markab, in Pegasus	343	36	14° 5' N.	19° 26' N.	20° 35'
Menkar, in Cetus	42	51	3° 16' N.	12° 37' S.	11° 26'
Procyon, in Canicula	112	6	5° 45' N.	15° 58' S.	22° 55'

Names and Constellations.	R.	A.	Declin.	Lat.	Long.
Pes Centauri	216	29	58S.	42	27
Regel, or Rigel, in Orion's Foot	76	8	27S.	31	13
1. Star in the Girdle of Orion	80	21	28S.	23	19
2. ——— ditto	81	25	21S.	24	20
3. ——— ditto	82	34	4S.	25	21
Scheat, in Pegasus	343	25	57N.	31	26
Sheder, in Cassiopeia	7	12	24N.	46	4
♂ Sirius, in Canis Major	99	0	26S.	39	11
♂ Spica, in Virgo*	198	34	4S.	2	20
Lower Pointer, in Urfa Major	162	18	30N.	45	16
Upper Pointer, in ditto, called Dubhe	162	42	52N.	49	12
Vindemiatrix, in Virgo	192	57	5N.	16	7

♂ The Stars marked thus *, in the foregoing Table, are those from which the distance of the Moon is calculated in the Nautical Almanack, for the purpose of ascertaining longitude.

D I A L O G U E VIII.

Containing some useful and necessary Problems on the Terrestrial Globe.

N. B. ($^{\circ}$) stands for degrees, ($'$) for minutes.

S E C T. I.

Pbilo. **Y**OU say, *Tyro*, that you understand what I have shewn you concerning the nature of the globes, and the appendants that belong to them; and, if so, you are fit for the following problems: but, if you think you are not perfectly master of these subjects, or do not understand what right Ascension, oblique Ascension, Azimuth, Almacanthers, &c. signify, or do not know what the greater or lesser circles are, and the particular uses of the Meridian, Horizon, Colures, Quadrant of Altitude, &c. then, pray, turn back, and read them over once more; for you will find that your understanding these will be a great help to you in the solution of geographical problems.

Tyro. I thank you for your care; but I understand them in general very well.

Pbilo. Then I will directly proceed to

PROB.

P R O B. I.

The Latitude of any Place being given, to rectify the Globe for that Place.

D E F I N I T I O N.

I Have already told you, that the latitude of any place is the same thing as the elevation of the pole above the Horizon; therefore, whatever the latitude be, suppose that of London $51^{\circ} 32'$ N. or that of Madrid $40^{\circ} 25'$ N. proceed thus:

Turn the pole on which the dial-plate is fixed towards the north part of the Horizon, slipping or moving the whole globe backwards or forwards, in the notches of the Horizon, till the Horizon cuts the Brazen Meridian, in $51^{\circ} 32'$ (viz. a little more than $51\frac{1}{2}$) so will the globe be rectified for the latitude of London; that is, the N. pole will then be elevated $51^{\circ} 32'$ above the Horizon; and London being brought to the Meridian itself, will then be in the Zenith, or right up, and at an equal distance from all parts of the Horizon.

Depress the pole till the Horizon cuts the Brazen Meridian at $40^{\circ} 25'$, and you will then have the position of the inhabitants at Madrid; and turning the globe, till Madrid comes to the Meridian, you will find it in the Zenith, or top of the globe, under $40^{\circ} 25'$.

Note. If it were required to rectify the globe for S. latitude, then you must elevate the S. pole to the given latitude instead of the N. pole; but this is better explained by the next problem.

P R O B.

P R O B. II.

The Latitude and Longitude of any Place being given, to find the same.

First, **Y**OU are to observe whether the longitude be reckoned from London, or from any other first Meridian; for on some globes the first Meridian begins at 23° , on others at 20° , and on Senex's globes at 18° W. from London; but, if once you know where the first Meridian is on the globe, it is very easy to know the difference between that and the Meridian of London, supposing it to begin from another place. As in most English authors the tables of longitude are counted from the Meridian of London, I here follow the same method.

See a farther account of longitude, **DIALOGUE VII. Sect. I. Defin. 14.**

E X A M P L E.

There are two certain places; one has $18^{\circ} 00'$ N. latitude, and $77^{\circ} 00'$ W. longitude. The other has $34^{\circ} 29'$ S. latitude, and $18^{\circ} 30'$ E longitude from London; I demand what places these are?

R U L E.

For the first place, I elevate the N. pole to $18^{\circ} 00'$ because it is $18^{\circ} 00'$ N. latitude. Then I turn the globe to the right-hand, or eastward (because the place lies westward) till $77^{\circ} 00'$ upon the Equator, counted from the Meridian of London (which on Senex's globe has a cypher thus (0) on the Equator) passes through, or under,
the

the meridian; or, in other words, I turn the globe, till $77^{\circ} 00'$ westward is brought under the meridian, and here I fix the globe with a quill thrust in betwixt the globe and the Horizon: then I look under the latitude $18^{\circ} 00'$ (which is in the Zenith) on the meridian on the top of the globe, and under $18^{\circ} 00'$ on the meridian, I find Port Royal, or Kingston, in Jamaica, the place required.*

For the second place I elevate the S. pole (though there is no occasion to elevate the pole barely to find a place; but it is better to do so, because you have then the real situation of the inhabitants) to the given latitude $34^{\circ} 29'$, and then turn the globe to the left-hand, or westward, till $18^{\circ} 30'$ E. longitude from London come under the meridian. Then I look under the latitude $34^{\circ} 29'$ on the meridian, and just under this I find the Cape of Good Hope, the place required.

Again, There are 3 places. The first $31^{\circ} 55'$ N. latitude, and $35^{\circ} 25'$ E. longitude: the second is $39^{\circ} 54'$ N. latitude and $116^{\circ} 30'$ E. longitude: and the last is $7^{\circ} 54'$ N. latitude, and $79^{\circ} 00'$ E. longitude; I demand the places.

Answer, Jerusalem, Pekin, and Candia, or Candy.

* Kingston being now considered as the capital of Jamaica, it is inserted on most modern globes instead of Port Royal; but the difference of their situation is so trifling as not sensibly to affect the result of the Problem.

P R O B. III.

The Latitude of any Place being given, to tell all those Places that have the same Latitude.

D E F I N I T I O N.

ALL those places, that have the same latitude, have the days and nights of the same length, at the same time; but not the very same hour of the day. See Dialogue VI. Sect. IV. Defin. 2.

R U L E.

Bring the given place to the meridian (suppose Madrid, in Spain, $40^{\circ} 25' N.$) then turn the globe, and all those places that pass under $40^{\circ} 25'$, have the same latitude as Madrid; which you will find to be Pekin, in China, Samarcand, in Tartary, Naples, in Italy, and Philadelphia, in America, nearly; for a few minutes are not to be minded in such cases.

P R O B. IV.

To tell the Difference of the Latitude of Places.

HERE are properly two questions, and consequently two answers. First, if the latitudes be both N. or both S. then subtract the less from the greater latitude, and the remainder is the difference or answer. Thus between London and Madrid is $11^{\circ} 7'$, the first being $51^{\circ} 32'$, and the other $40^{\circ} 25'$. And between Candy and Stockholm is $51^{\circ} 26'$, for
Stockholm

Stockholm is about $59^{\circ} 20' N.$ and Candy $7^{\circ} 54' N.$

Secondly, If one place lie on the N. and the other on the S. side of the Equator; that is, if one be in N. and the other in S. latitude, then add them both together, and their sum is the difference of the latitude required.

Thus Copenhagen is $55^{\circ} 41' N.$ and Botany-Bay $33^{\circ} 50' S.$ these added together make $89^{\circ} 31'$, the difference required.

P R O B. V.

The Longitude of any Place being given from any Meridian, to tell those Places that have the same Longitude.

THIS is done after the same manner as the other, only here the answer will be on the Equator, as the others were on the Meridian.

I would know what places have the same longitude as London, and the same longitude as Petersburg, in Russia.

R U L E.

Bring London to the Meridian, then all those places on the Globe (from the N. pole to the S.) that lie under the edge of the Meridian, have the same longitude as London. Thus, Alençon, in France, Valencia, in Spain, and Fort Nassau, and Fort Mina, in Guinea, have the same, or very nearly the same longitude as London.

And Constantinople, in Turkey, and Alexandria, in Egypt, have very nearly the same longitude

gitudeas Petersburg : also Scandaroon, Antioch, and Tripoli, in Syria, have the same longitude; viz. about $36^{\circ} 30'$ E. from London.

P R O B. VI.

To tell the Difference of the Longitude of Places.

(See Prob. XXVI.)

D E F I N I T I O N.

 *Note 1.* No place can exceed, or be above 180 d. of longitude from another place; for 181 d. E. longitude is more properly 179 d. W. longitude, for 181 d. taken from 360 d. there remains 179 d. which is nearer to the given place than 181 d.

R U L E.

HERE also there are two questions, and consequently two answers, as in Prob. IV. First, If the places lie both E. or both W. of the first Meridian, or the line you reckon the longitude from; viz. if they both have E. or both W. longitude, then subtract one from the other, you have the difference.

Thus, I find Jerusalem has $35^{\circ} 25'$ E. longitude from London, and Pekin $116^{\circ} 30'$ E. longitude; therefore, I subtract $35^{\circ} 25'$ from $116^{\circ} 30'$ and there remains $81^{\circ} 5'$ difference of longitude E. or W. that is, Pekin is $81^{\circ} 5'$ E. longitude from Jerusalem; or Jerusalem is $81^{\circ} 5'$ W. longitude from Pekin.

Secondly, If one place have E. and the other W. longitude from the first Meridian (suppose London, or any other Meridian) then add their
longi-

longitudes together, and the sum is the difference of longitude required.

E X A M P L E.

I would know the difference of longitude between Jerusalem $35^{\circ} 25'$ E. of London, and Port Royal in Jamaica $77^{\circ} 00'$ W.

Here, as one is E. and the other W. I add $35^{\circ} 25'$ and $77^{\circ} 00'$ together, and their sum makes $112^{\circ} 25'$, the difference of longitude. That is, Jerusalem is $112^{\circ} 25'$ E. of Port Royal, or Port Royal is $112^{\circ} 25'$ W. of Jerusalem.

Note 2. If the difference of longitude after addition exceeds 180 d. take it out of 360 d. for that is the true longitude required. See *Note 1.*

E X A M P L E.

Pekin, in China, is $116^{\circ} 30'$ E. longitude, and Port Royal is $77^{\circ} 00'$ W. I add these sums together, and find it $193^{\circ} 30'$, difference of longitude; but, because it is more than 180° I subtract $193^{\circ} 30'$ from 360° , and there remains $166^{\circ} 30'$, the difference required.

Tyro, Sir, I heartily thank you for this explanation, which I understand very well.

P R O B. VII.

The Day of the Month being given, to find the Sun's Place in the Ecliptic

R U L E.

THE day of the month being given, look on the inner calendar on the new globes, and

and you have the sign and degree of that sign that the sun is in on that day, according to the New Stile.

If it be upon old globes, look on the outward calendar, you have the sign and the degree of the sign.

N. B. You may further observe, that the calendar used throughout Europe is the calendar for N. S. viz. New Stile, and is always known from the other, because it has the Saints Days, and several other things written upon it on the Horizon.

EXAMPLE.

I would know the sun's place in the ecliptic, on May the 21st, N. S. March the 21st, June the 21st, September the 22^d, and December the 21st.

I look for these days of the months in order as they stand in the new calendar; viz. for N. S. before described, and right against the day of the month in the innermost circle on the Horizon, I find the sun's place among the signs.

Thus, right against May the 21st, I find ♊ of π Gemini: and also on March the 21st, I find he enters ♈ Aries: on June the 21st, he enters ♋ Cancer: on September the 22^d, he enters ♎ Libra: and on December the 21st, he enters ♏ Capricorn.

 *Note*, That in every problem and operation, except Old Stile be mentioned, it is to be understood for New Stile; viz. N. S. and latitude always means N. latitude, except expressed S.

PROB.

P R O B. VIII.

The Sun's Place being given, to find the Day of the Month.

R U L E.

THIS is only the reverse of the former problem: for having the sun's place given, seek it in the innermost circle among the signs; then against that degree in the calendar N. S. you have the day of the month required.

E X A M P L E.

I would know what time of the year it is, viz. what month, and what day of the month it is when the sun is in 1° of π , as also when he enters φ , ϖ , ϵ , and ψ . Proceed according to the rule, and you will find the days to be May the 21st, March the 21st, June the 21st, September the 22d, and December the 21st.

P R O B. IX.

The Latitude and Day of the Month being given, to find the Sun's Place in the Ecliptic, and rectify the Globe for Use.

R U L E.

FIND the sun's place on the Horizon by Prob. VII. and having noted what degree he is in, look upon the ecliptic on the globe, and find the same sign and degree as you did on the Horizon, then bring this degree of the ecliptic

ecliptic very carefully to the graduated edge of the Brazen Meridian, and holding the globe steady, turn the index exactly to the upper 12, which represents 12 at noon, and thus is the globe rectified for that day, and the degree of the ecliptic that lies under the Meridian, represents the sun's place at noon, or 12 o'clock that day.

 The Astronomical day is reckoned from, or begins at, 12 o'clock at noon; and, if you fix the quadrant of altitude to the latitude in the Zenith, the globe will be completely rectified; but more of this by and by.

P R O B. X.

To tell the Declination of the Sun on any Day of the Year.

DEFINITION.

DDeclination of the sun is his variation from the Equator, either Northward or Southward.

N. B. His greatest declination northward is 23 d. 30 m. which is on June the 21st, and his greatest declination southward is 23 d. 30 m. December the 21st: but on March the 21st, and September the 22d, when he enters ♊ and ♎, he has no declination at all, but is in the Equator itself; and then the days and nights are equal to all the inhabitants on the globe.

R U L E.

Having found the sun's place in the ecliptic for the given day, bring it to the Brazen Meridian,

Meridian, and observe what degree of the meridian it lies under, and whether it be on the N. or on the S. side of the Equator, for that is the declination required, which is called N. or S. declination accordingly.

E X A M P L E.

Proceed according to the rule, you will find, on April the 21st, the sun has $12^{\circ} 00'$ N. declination, and on May the 21st, he has $20^{\circ} 30'$ N. declination: but on October the 27th, he has $12^{\circ} 50'$ S. declination, and on January the 30th, he has 18° S. declination nearly.

P R O B. XI.

The Latitude and Day of the Month being given, to tell the Sun's Meridian Altitude; viz. his Height at Noon.

R U L E.

BRING the sun's place to the Meridian, and observe what degree of the Meridian the sun's place is under; for those degrees on the Meridian that are intercepted, or lie between the South verge of the Horizon, and the degree which is over the sun's place on the Meridian, counted on the Meridian, is the sun's Meridian Altitude required.

Note, The sun's declination, when north, added to the complement of the latitude, will give the Meridian Altitude; but when south subtract it therefrom, and the remainder will be the Meridian Altitude.

E X A M P L E.

I would know in the latitude $51^{\circ} 30'$, on May the 21st, the sun's Meridian Altitude, as also
his

his Meridian Altitude on November the 5th. I proceed according to the rule, and find his Meridian Altitude, May the 21st, to be 59° ; but on November the 5th, he has but 23° Altitude.

Proceed thus, and you will find his Meridian Altitude, in the latitude of 40° on the same days, to be 70° , and 34° : but in the latitude of 20° , on May 21, he will have 90° of altitude, or be right over head that day to the inhabitants in that latitude, which shall be further explained by and by.

P R O B. XII.

The Latitude of the Place (suppose London) and Sun's Meridian Altitude being given, to tell the Day of the Month supposing it were lost.

R U L E.

THIS problem is the reverse of the last; for you are only to set the globe to the latitude, then count from the S. verge of the Horizon, as many degrees on the Meridian upward as the given height is; then turn the globe till some point of the ecliptic comes under that degree of the Meridian, which will be the sun's place that day, which seek in the circle of signs on the Horizon, and against it is the day required.

E X A M P L E.

In the latitude of $51^{\circ} 30'$, on two certain days, I observed the sun's Meridian Altitude to be 59° and $23^{\circ} 30'$; I demand what days they are?

Proceed

" Proceed according to the rule, you will find the one to be May 21, or July 24; the other November 3, or February 8. For it is to be observed, that the answer will be returned differently, according as you use the ascending or descending signs; for every degree of the ecliptic has another corresponding to it in altitude, except the two tropical points of Cancer and Capricorn.

P R O B. XIII.

*The Latitude and Day of the Month being given,
to tell the Sun's Altitude at any Time.*

E X A M P L E.

ON May the 21st, at 9 in the morning, and at 5 in the afternoon at London, I would know the sun's altitude.

R U L E.

Rectify the globe for the latitude, and bring the sun's place ($1^{\circ} \Pi$) to the meridian, and the index to the upper 12 on the dial-plate; then fix the quadrant of altitude in the Zenith; (viz. the left edge of the nut must be fixed on the meridian at $51^{\circ} 30'$) then turn the globe till the index points to the hour, viz. 9 in the morning; this done, fix the globe by thrusting in a quill between it and the Horizon; lastly, turn the quadrant about, till the graduated or figured edge touch the sun's place (viz. $1^{\circ} \Pi$) and the degrees on the quadrant, counted from the Horizon upward on the quadrant, is his height at that
F time;

time; viz. $43^{\circ} 30'$. Then turn the globe till the index points to 5 in the afternoon; and also turn the quadrant on the W. side (without unscrewing it) till it touches the sun's place; and you have about 24° on the quadrant, his altitude at that time.

But at North Cape (viz. N. latitude 72°) at 9 in the morning May 21, he will be but about 32° high.

P R O B. XIV.

The Latitude (suppose London) and the Sun's Altitude and Day of the Month being given, to tell the Hour.

THIS is but the reverse of the last problem, only it will have two answers; viz. the hour may be either in the morning or afternoon.

R U L E.

Rectify the globe as before directed, and turn the globe and the quadrant on the E. side, till the quadrant touches the sun's place at the given height, (which by the last, on May 21, at 9 in the morning, was found $43^{\circ} 30'$), then look at the index, and it will point to the hour; turn it W. till the sun's place touch the same degree on the quadrant on the W. side, and you will have the time in the afternoon.

E X A M P L E.

Thus on May the 21st, at London, when the sun is $43^{\circ} 30'$ high, it is either 9 in the morning, or three in the afternoon.

Note,

Note. When the sun's place and quadrant are on the E. side of the meridian, it is morning hours; but when the sun's place is on the W. part of the meridian, or westward of it, it is afternoon.

P R O B. XV.

The Latitude being given, to tell the rising and setting of the Sun, and the Length of the Day and Night, at any Time of the Year.

R U L E.

RECTIFY the globe (viz. elevate it for the latitude, bring the sun's place to the meridian, and index to the upper 12), then turn it till the sun's place comes even with or lies against the inner verge on the E. side of the Horizon, then the index will shew you the time of the sun's rising; turn it to the W. side or verge of the Horizon, and the index will shew you the setting. Or the latter part of the problem may be solved thus: having got the hour the sun rises, count how many it wants of 12; for so many hours will it set after 12. Thus; if the index points to 4 in the morning at rising, it will of course set at eight at night; if it points any day at half an hour past 7 at rising, it will set at half an hour past 4; both being four hours and a half from 12 at noon.

Note 1. If you double the number of hours between sun-rising and 12 it will give you the length of the Day from sun-rising to setting.

Note 2. If you subtract the length of the Day from sunrise to sun-setting, from 24, the remainder shews you the length of the night, twilight included. See Prob. XXV.

Proceed thus, and you will find the sun, on May 26, at London, to rise about 4 in the morning, and set at 8 at night. Now double what he wants of 12 at rising, viz. 8 hours, and it gives the length of that day at London, viz. 16 hours.

But at Madrid, on the same day he rises about $\frac{3}{4}$ past 4, and sets $\frac{1}{4}$ past 7 at night. And at Stockholm, on the same day he rises at about $\frac{1}{4}$ past 3, and consequently the days are $17\frac{1}{2}$ hours long there.

P R O B. XVI.

To tell the Length of the longest and shortest Day at London, Latitude N. $51^{\circ} 30'$ and at Stockholm, Latitude N. $59^{\circ} 20'$.

R U L E.

YOU proceed the same way in this as in the last problem, only instead of bringing 6° of π , as before, you now work with 1° of α , or rather 30° of π , for then the sun enters Cancer on June 21, or longest day.

You will find him, therefore, rise at London, June the 21st, at 48 m. past 3 in the morning, which wants 8 h. 12 m. of 12.; this doubled gives 16 h. 24 m. for the longest day at London.

Then work with 1° of Capricorn, or rather 30° of Sagittarius, for the shortest day; viz. bring

bring 30° of Sagittarius to the meridian, and the index to 12, and you will find the sun rises 12 m. past 8, which wants 3 h. 48 m. of 12; this doubled gives 7 h. 36 m. the length of the shortest day.*

Proceed now for Stockholm (viz. $59^{\circ} 20'$ N. latitude) and if you work in the same manner, you will find the longest day to be about $18\frac{1}{2}$ h. and the shortest $5\frac{1}{2}$ h. And thus, for any other latitude, or place, not exceeding $66^{\circ} 30'$; for there the days will be 24 h. and, if you go to a greater latitude, either N. or S. you will find them 30 h. long, or even 2, 3, 4, or 5 days, nay 2, 3, 4, or 5 weeks, or as many months, which I shall explain in a problem by itself hereafter.

Tyro. This is a little surprizing, indeed, and at present I must own seems very strange to me.

Philo. I assure you it is not more strange than true, as you will plainly perceive when we come to treat of it.

P R O B. XVII.

To tell the Sun's right Ascension.

WHAT right ascension is, you will find in Dial. VII. Sect. I. Art. 6.

Bring the sun's place to the Brazen Meridian, and note what degree of the Equator is cut by the meridian, for that is his right ascension required.

* The length of days given above, is exclusive of Refraction; for if that be taken into the account, the longest day will be 16 h. 34 m. and the shortest 7 h. 44 m. but this would not correspond with the operations of a globe.

E X A M P L E.

I would know the sun's right ascension, on March the 21st, June the 21st, September the 22d, and December the 21st.

I find the sun's place for these different days, and bringing it to the meridian, I find the meridian cuts the Equator in (0) in (90) in (180) and in (270°) his right ascension required.

Note. When the sun enters ♈, March the 21st, he has no right ascension, because it is counted from, or begins at ♈; therefore, on March the 20th, he must have his greatest right ascension, viz. 360°.

P R O B. XVIII.

To find the Sun's oblique Ascension and Descension at any Time, and in any Latitude.

See Oblique Ascension and Descension, Dial. VII. Sect. I. Article 7, 8.

N. B. Though the latitude is not required in finding the right ascension, because the Equator will be cut in the same place by the meridian, whether the pole be elevated or depressed; yet in the oblique ascension, the Horizon will cut the Equator in different degrees according to the latitude, as will appear from the work and your own reflection.

R U L E.

1. **R**ECTIFY the globe, and bring the sun's place down to the eastern verge of the Horizon; then observe what degree the Horizon cuts the Equator in, for that is the oblique ascension required.

2. Turn

2. Turn the globe till the sun's place comes to, or lies level with the western verge of the Horizon, and the degree of the Equator cut by the Horizon, is the oblique descension required.

Thus on March the 21st, June the 21st, September the 22d, and December the 21st; viz. when the sun enters ♈, ♊, ♉, and ♏, you will find his oblique ascension at London to be (0) (56) (180) and (304).

And on the same days his oblique descension will be (0) (123) (180) and (237½).

P R O B. XIX.

The Latitude and Day of the Month being given, to tell the Sun's ascensional Difference; viz. how much he rises or sets before and after 6; and, consequently, to tell the Length of the Days, supposing there were no Index to the Globe.

R U L E.

BY Prob. XVII. and XVIII. find the sun's right, and oblique ascension; then subtract the oblique from the right ascension, or the contrary, and the remainder is the ascensional difference required; which divide by 15, the degrees of the Equator that pass through the meridian in 1 hour (or $7\frac{1}{2}$ in $\frac{1}{2}$ an hour) and the quotient gives the answer in time that the sun rises and sets before and after 6. See an example in figures, how to convert degrees and minutes into time, Prob. XXVI.

EXAMPLE *for* LONDON.

On May the 26th, I find the sun in 6° of π , and his right ascension 64° , and on the same day his oblique ascension is 34° ; now 34° from 64° there remains 30° , his ascensional difference; which divide by 15, and the quotient gives two hours, the time that he rises before, or sets after 6.

This you may prove by Prob. XV. for you will find he rises at 4, and sets at 8, May the 26th.

But on December the 6th, his right ascension is 256° , and his oblique ascension is 286° , their difference is 30° which is two hours, that he rises after, or sets before, 6.

N. B. The right exceeds the oblique ascension from γ to α , when the sun rises before 6; but the other half year that he rises after, or sets before, 6, the oblique exceeds the right ascension.

P R O B. XX.

The Latitude and Day of the Month being given, to find the Sun's Amplitude; viz. his Distance from the E. or W. Point at his rising and setting, and the Point of the Compass he rises and sets upon.

R U L E.

THE globe being rectified, bring the sun's place to the eastern verge of the Horizon (which shews his rising) then the degrees upon the innermost circle of the Horizon, counted from

from the true E. point to the place which the sun's place lies against on the Horizon, shew you the sun's amplitude.

EXAMPLE *at* LONDON.

Proceed according to the rule, and you will find the sun's amplitude (May the 21st) at rising to be about 34° from the East to the N. and at setting 34° from the W. to the N. and the point he rises upon is N. E. by E. and he sets N. W. by W. But on November the 5th, he has about $25^{\circ} 30'$. amplitude from the E. to the S. and at setting $25^{\circ} 30'$ from the W. to the S. The point he rises upon is E. S. E. and the point he sets upon is W. S. W.

P R O B. XXI.

The Latitude, Day, and Hour being given, to find the Sun's Azimuth; viz. his Distance from the E. and W. or from the N. and S. Points at any Time.

See Azimuth, Dial. VII. Sect. I. Article 11.

R U L E.

RECTIFY the globe, then turn it round till the index points to the given hour; this being done, turn the quadrant, till it touches the sun's place for the given day; and then the quadrant will cut the Horizon in the Azimuth required from the E. or W. points, or from the N. or S. points, for you may reckon from either,

either, only then name it properly and accordingly.

Thus on August the 17th, at 9 in the morning, the sun will have about 30° Azimuth from the E. to the S. or, which is the same, 60° from the S. to the E. for 60° and 30° make 90° the whole quarter from E. to S.

N. B. Some authors call this 60° S. amplitude; but others call it 30° S. amplitude; that is, 30° from the E. to the S. as I said before.

This will appear yet plainer, if we would know the Azimuth of the sun the same day, at 11 in the morning, which is $68^{\circ} 30'$ from the E. to the S. or $21^{\circ} 30'$ from the S. to the E.

But on May the 21st, at 3 in the afternoon, he will have 25° Azimuth from the W. to the S. viz. 65° Azimuth from the S. to the W. And at $\frac{3}{4}$ past 5, his Azimuth is 10° from the W. to the N. or 80° from the N. to the W.

Tyro. Sir, I understand the demonstration quite well; but how am I to express, or name, the Azimuth in general

Philo. By the words North and South, because it will always be either northward or southward, reckoning from the E. and W. points, either North or South.

Thus as before, August the 17th, at 9 in the morning, the sun has 30° S. Azimuth (viz. from the E. point southward) but on May the 21st, at $\frac{1}{2}$ h. past 4 in the morning, he has 30° N. Azimuth; viz. 30° from the E. northward.

PROB.

P R O B. XXII.

*The Latitude and Azimuth being given on any Day,
to tell the Hour, or Time of the Day.*

R U L E.

THIS is the reverse of the former problem, for the globe being rectified, turn the quadrant of altitude to the given degree of Azimuth (from the E. or W. point on the Horizon) and there hold the quadrant steady with one hand, and with the other turn the globe, till the sun's place for the given day touches the figured edge of the quadrant, and the index will point to the hour, or time, required.

EXAMPLE for LONDON.

On August the 17th, I observe the sun's Azimuth to be 30° from the E. to the S. I would know the hour. Answer, 9 in the morning.

Again, on May the 21st, I find his Azimuth 10° from the W. to the N. what is the hour? Answer, $\frac{3}{4}$ past 5 in the afternoon.

P R O B. XXIII.

*The Latitude, Day, and Hour being given, to tell
the Sun's Almacanther.*

D E F I N I T I O N.

ALMACANTHERS are circles of altitude parallel to the Horizon, and whose poles are the Zenith and Nadir; so that you may ima-

gine as many circles of altitude, viz. almacanthers, as you please.

R U L E.

The almacanthar is found the same way as the altitude of the sun at any time; therefore, I refer you back to Prob. XIII.

P R O B. XXIV.

The Latitude and Day being given, to tell what other Day of the Year will be of the same Length.

R U L E.

HAVING found the sun's place for the given day, bring it to the meridian, and observe well its declination; then turn the globe till some other degree of the ecliptic comes to the same degree of declination under the meridian; this being done, see what day of the month answers to the sun's place then under the meridian, for that is the day required; which you may easily prove by Prob. XV.

I would know what day is of the same length as May the 26th, and of the same length as April the 17th. Answer, July the 16th, and August the 24th.

Note. These last 8 Problems, as also Prob. IX. and X. are common to both globes; but are inserted here, because many persons have a terrestrial, that have not a celestial globe.

The

The following Problems more particularly concern, or belong to, the terrestrial globe.

P R O B. XXV.

The Latitude and Day of the Month being given, to tell the Beginning, Ending, and (consequently) the Length, or Continuance, of Twilight.

D E F I N I T I O N.

TWILIGHT is that faint light which begins immediately after the sun sets in the evening, and continues till he is 18° below the Horizon; and begins in the morning, when the sun comes within 18° of the Horizon on the E. side, and ends when he rises.

Tyro. I have heard that this Problem is very difficult in comparison of some others.

Philos. It is something longer in its operation, but very easy, if you mind the rule and the operation together.

O B S E R V A T I O N.

As you were told that twilight begins and ends when the sun is 18° below the Horizon, and as the quadrant of altitude reaches no farther than the Horizon, therefore the rule is this.

R U L E.

The globe being rectified, &c. bring the degree directly opposite to the sun's place to the quadrant of altitude, so that it touches just
 18°

18° on the quadrant, (then it is plain that the sun's real place will be depressed 18° below the Horizon) then look on the index of the horary circle, for that will point (if among the morning hours) to the beginning, or (if among the evening hours) to the ending of twilight.

Note 1. What I mean by the degree opposite to the sun's place, is this; it is that degree of the ecliptic, opposite to, or 180° from the given place of the sun. Thus, suppose the sun were in ♈, then I bring its opposite sign (viz. ♎) to 18° on the quadrant, so will ♈ be depressed 18°, and the index will shew the hour.

Tyro. Sir, I now understand it very clearly.

Philo. Proceed then according to the rule, and you will find that on March the 21st, and September the 22d, twilight begins about 4 in the morning, and ends about 8 at night.

The sun on these days, you know, rises and sets at 6. Add, therefore, the length of morning and evening twilight to 12 hours (the length of the days then) and it gives 16 hours; this subtracted from 24 hours, leaves 8 hours, the length of the real, or dark, night.

So also on April the 24th, twilight begins about $\frac{1}{2}$ past 2, ends about $\frac{1}{2}$ past 9, and lasts in all 4 h. 40 m. But on December the 20th, it begins nearly at 6, and ends at 6, and lasts in all 4 h. 14 m.

Note 2. There is no real night at London (but twilight) from May the 22d, to July the 20th, the sun all that time being less than 18° below the Horizon.

P R O B. XXVI.

The Hour where you are being given, to tell what Hour it is in any other Part of the World. See Prob. VI.

R U L E.

BRING the given place to the meridian, and set the index at the given hour; then turn the globe till the other place, or places, come under the meridian, and the index will point to the real time in the place required.

E X A M P L E.

When it is 2 o'clock in the afternoon at London, I would know the time at Jerufalem, and at Port Royal, or Kingfton, in Jamaica.

Proceed according to the rule, and you will find, that when it is 2 in the afternoon at London, it is 22 minutes past 4 at Jerufalem; and but 52 minutes past 8 in the morning at Port Royal.

Another METHOD.

I told you in Prob. XIX. that 15° on the Equator make 1 hour of time; therefore this Problem may be solved by common division, for having the difference of the longitude of any two places (taken from a map) divide it by 15, the quotient is the difference of hours; and if any degrees remain, allow 4 m. for every degree, and so in proportion for the odd minutes or miles.

Thus I find by Problem VI. Jerusalem is $35^{\circ} 25'$ E. longitude of London; I divide, therefore, $35^{\circ} 25'$ by 15, and the quotient is 2 hours, and the remainder is $5^{\circ} 25'$, which is 5 times 4, or 20 m. and the odd 25 m. or miles, is nearly 2 m. so that the difference is 2 hours 22 m. and as Jerusalem is east of London, it has its hour before us, therefore it is 22 m. past 4 in the afternoon.

Again, Port Royal is $77^{\circ} 00'$ W. of London; this converted into time as before is 5 h. 8 m. that Port Royal has its time later than London; for when it is noon at London, it wants 8 m. of 7 in the morning at Port Royal.

P R O B. XXVII.

The Day of the Month being given, to tell those Inhabitants that will have the Sun in their Zenith (or over their Heads) on that Day.

O B S E R V A T I O N.

THIS cannot happen to any other inhabitants, but those in the Torrid Zone, that is, to such as have not above $23^{\circ} 30'$ of latitude, either N. or S.

R U L E.

Bring the sun's place to the meridian, and observe exactly his declination for that day; then turn the globe any way, and observe what places pass under that degree of declination on the meridian; for all such will have the sun directly

directly over their heads some time or other on that day.

E X A M P L E.

I would know what inhabitants, or places, will have the sun in their Zenith on May the 21st.

Proceed as directed by the rule, and you will find the city of Mexico, Campeachy, St. Jago in Cuba, Owhyhee, and many other places that will pass under that degree of declination (viz. 20° N.) and will have the sun in their Zenith on that day.

Also on April the 16th, the inhabitants of Porto Bello, Carthagena, Isle of Trinidad, Cochin in India, the Philippine islands, and Sierra Leone, (the new English Settlement on the West coast of Africa) will have the sun that day in, or near their Zenith.

P R O B. XXVIII.

The Day and Hour being given in any Place, to tell those Inhabitants, or that Place, to which the Sun is then vertical; viz. in the Zenith.

R U L E.

BRING the given place to the Brazen Meridian, and turn the index to the given hour; this done, turn the globe till the index points to the upper 12, or noon; then look under the degree of the sun's declination on the globe for that day, for that is the very spot, or place, to which the sun is then vertical.

EX-

E X A M P L E.

On May the 10th, at 8 m. past 5 in the afternoon, at London, I would know what place has the sun then in its Zenith. Answer, Port Royal, in Jamaica.

N. B. There are two days in which the sun is vertical to all the inhabitants of the Torrid Zone; which must be when the sun has the same declination; and in this Problem the other day will be August 2; viz. the same declination as on May the 10th.

Thus also will you find that, when it is 33 m. past 6 in the morning at London, on April the 10th, and August the 31st, the inhabitants at Candy, in the island of Ceylon, will have the sun then in their Zenith.

P R O B. XXIX.

To tell the Distance of one Place from another in Degrees and Minutes (viz. Miles) in an Arch of a great Circle, also their Bearing, or Situation, in respect of each other.*

R U L E.

BRING one of the places to the meridian, and elevate the globe for the latitude of it, and fix the quadrant in the Zenith: then turn the globe till the quadrant touches the other

* Note, 60 miles, or minutes, are reckoned a degree in general; but this is a vulgar error; for it is proved that every degree on the earth's surface in every great circle (such as the Equator, Meridian, &c.) is $69\frac{1}{2}$ miles; therefore, multiply the degrees by $69\frac{1}{2}$, you have the distance in English miles.

place,

place, and the degrees on the quadrant between place and place shew the distance; and the quadrant at the same time will cut the Horizon in the point of the compass, called the bearing, or situation, from the first place.*

E X A M P L E.

I would know the distance from London to Port Royal, Jerusalem, and Moscow; as also their situation in respect of London.

Proceed according to the rule, and you will find from London

	Deg.		Miles.
To Port Royal	68	viz. nearly	4726 W.
To Jerusalem	$32\frac{1}{2}$		2259 E. S. E.
To Moscow	$22\frac{1}{2}$		1564 E. N. E.

P R O B. XXX.

The Latitude and Day being given, to tell what Time the Sun will be due E. or W.

Tyro. **T**HIS is easy, I think; for as the sun is always due N. and S. at 12 at night, and at 12 at noon, I suppose he will be due E. and W. at 6 in the morning, and 6 in the evening.

Philo. I thought you would stumble upon this general error; but you will soon see your mistake.

* The Bearing is here to be understood on the Arch of a great Circle, which is by an angle of Position, very different from a Bearing by the Compass.

R U L E.

R U L E.

Rectify the globe and quadrant as before directed; then turn the quadrant till it touches the E. or W. point of the Horizon; this done, turn the globe till the sun's place for the given day comes to the edge of the quadrant (holding the quadrant to the E. or W. point) so will the index of the horary circle point to the hour of his being due E. or W. on that day.

Proceed thus, and you will find about 5 m. past 7 in the morning, on May the 21st at London, the sun will be due E. and about 5 m. before 5 in the evening due W. On June the 21st, he will be due E. about 22 m. past 7 in the morning, &c. but on December the 21st, he is due E. about 45 m. past 4 in the morning, and due W. about 15 m. past 7 in the evening.

P R O B. XXXI.

To find the Antœci to any Place.

See Antœcians, Dialogue VI. Sect. IV. Article I.

R U L E.

BRING London (or the given place) to the meridian, and count from the Equator on the meridian southward the same number of degrees of S. latitude, as London has N. (viz. $51^{\circ} 32'$) and close to the edge of the meridian make a dot, for that is the place of the Antœci to London.

P R O B.

P R O B. XXXII.

To find the Periœci to London, or any other Place.

See Definition of Periœcians, Dial. VI. Sect. IV. Article 2.

R U L E.

BRING London to the meridian, and turn the globe till 180° of the Equator pass from London under the meridian; then under the same Latitude as London (viz. under $51^{\circ} 32' N.$) at the edge of the Brazen Meridian make a dot, for that is the place of the Periœcians required.

P R O B. XXXIII.

To find the Antipodes to London, or any other Place.

See Definition of Antipodes, Dial. VI. Sect. IV. Article 3.

R U L E.

BRING London to the meridian, and turn the globe till 180° pass through the meridian, then count $51^{\circ} 32'$ southward on the meridian, and under it make a dot, for that is the place of the Antipodes.

Or rather thus:

Bring London to the meridian, then slip the globe in the notches of the Horizon; viz. depress the pole, till London lies at the N. verge of the Horizon, just at the edge of the meridian;

dian; then at the S. point of the Horizon, close to the meridian, make a dot, for that is the place of the Antipodes to London, which you will find to be in the Great South Sea, $51^{\circ} 32'$ S. latitude, and 180° longitude, near New Zealand.

P R O B. XXXIV.

The Time of an Eclipse of the Sun or Moon being given, to find all those Countries, or Parts of the Globe, in which it will be visible.

R U L E.

1. **F**OR the Sun:—Find the place to which the Sun is vertical at the time of the eclipse, by Problem XXVIII, elevate the Globe for the latitude of that place, and bring it to the Zenith or top of the globe; then to all places in the upper hemisphere, if the eclipse be large, part of the Sun will appear visibly obscured; but if the eclipse be small, in places near the horizon, it will be invisible on account of parallax.

2. For the Moon:—Find the place to which the Sun is vertical at the time of the eclipse, as before directed; then find the Antipodes to that place, viz. the point exactly opposite thereto, (which will be the place of the Moon at that time) bring this point to the Zenith; then to all the inhabitants of the upper hemisphere, the eclipse will be visible; to those of the lower one invisible.

E X-

E X A M P L E. 1.

Sept. 5, 1793, the Sun will be eclipsed at eleven in the morning;—Query, in what parts of the globe will this eclipse be visible?

Proceed according to the rule, and you will find the Sun vertical to a part of the Coast of Guinea, in Africa, a little North East of Calabar; which point being brought to the Zenith, Europe, Africa, part of Asia, and of North and South America, will appear in the upper hemisphere, and in each of these the eclipse will be visible, but more particularly in Africa. The Sun will be nearly vertical to *Sierra Leone* at the end of the eclipse.

E X A M P L E 2.

Feb. 14, 1794, there will be a total, and almost central, eclipse of the Moon, at ten o'clock at night; on what parts of the globe may it be seen?

Proceed as before directed, and you will find the Sun vertical to a part of the South Sea, a little North of Otaheite and the Society Isles, the opposite point to which (viz. the place of the Moon at that time) will be found in Africa, near the source of the river Nile; which point being brought to the Zenith, Europe, Africa, great part of Asia, and Brazil in South America will appear above the Horizon, and in all these the eclipse will be visible.

Note, The time given in each of the foregoing examples is that of the middle of the eclipse (it being then more extensively conspicuous) but to find all the places at which any eclipse will be visible, the same operation must be repeated for the beginning and end, finding the place where the sun is vertical, &c. at each time.

P R O B.

P R O B. XXXV.

The longest Day in any Latitude being given (suppose London $16\frac{1}{2}$ Hours) to tell in what other Latitude the longest Day is 1, 2, 3, &c. Hours longer than in the given Place.

R U L E.

RECTIFY the globe for the given latitude (viz. London) and bring the solstitial colure (viz. ∞) to the meridian; then where the Horizon cuts the tropic of ∞ make a dot on the tropic at the verge of the Horizon: this done, turn the globe westward, till $7^{\circ} 30'$ of the Equator pass under the meridian, and then make a second dot on the tropic against the Horizon as before; then turn the globe back to its first position (viz. to ∞) and then elevate the pole, till the 2d dot appears at the edge of the Horizon, and the Horizon will cut the meridian in the latitude required.

Proceed as above, and you will find that in the latitude of $56^{\circ} 20'$, the days are 1 hour longer than at London, which you may easily prove by Prob. XVI.

2. If you want to know the latitude where the day is two hours longer than at London, proceed as before, only instead of causing $7^{\circ} 30'$ to pass under the meridian, you must now turn the globe till 15° pass under the meridian, and make then a dot on the tropic, as before.

3. If you want for 3 hours longer, make $22^{\circ} 30'$ pass through the meridian, and proceed

as

as before; and thus for every hour, cause $7^{\circ} 30'$ more to pass under the meridian.

Note, If you want to know the latitude where the longest day is an hour shorter than at London, only turn the globe eastward, instead of westward, till $7^{\circ} 30'$ pass through the meridian, and make a dot on the tropic, and depress the pole till this lies even with the Horizon, you will find the latitude about $45^{\circ} 30'$. Thus for two hours longer about 60° , for 4 hours about $64^{\circ} 20'$; but for 2 hours shorter the latitude is about $35^{\circ} 30'$. This problem shews you the difference of climates.

P R O B. XXXVI.

Any Time not exceeding six Months given, to tell that Latitude, or those Places, where the Sun will not set for all that Time.

Note, That 28 days are here reckoned to the month. Bring the given time into days, and take the half of the number of days; but remember to abate 1 if the half exceeds 36. Then count from Cancer on the ecliptic the same number of degrees as the half amounted to, and where this reckoning ends make a dot on the ecliptic. Lastly, Bring this dot to the meridian, and as many degrees as are intercepted, or lie, between the dot and the pole itself, counted on the meridian, is the latitude required.

E X A M P L E.

I Demand the place, or latitude, where the sun does not set for the space of 4 months and 16 days.

G

This

This is 128 days, the half is 64° , abate 1° and it is 63° ; this I count from ϖ on the ecliptic, and make a dot, and bringing it to the meridian, I find there are nearly 80° between the dot and the pole; viz. the latitude is 80° , which is at Smith's Inlet, the upper part of Greenland.

So also in the latitude of 85° , he sets not for 5 months and 2 weeks. And in the latitude of $86^{\circ} 30'$ not for 5 months, 3 weeks, and 3 days; and in the latitude of 90° , not for 6 months; viz. from March the 21st to September the 22^d.

Tyro. This appears, now, very plain to me, but I know the generality of persons believe it to be false, for want of consideration.

Philo. You see it is evident, for under the pole, in the latitude of 90° , when the sun enters ϖ he begins to rise, and does not set with the inhabitants there (if there be any) till he enters ϖ ; viz. for 6 months.

Tyro. I see it, Sir, very clearly; but, pray, have they not also a great share of twilight? And are not the inhabitants at the contrary pole in darkness for a long time?

Philo. Yes, and so are the inhabitants in the N. part, when the sun is in the tropic of ϖ . This is plainly demonstrated by the next Problem.

P R O B.

P R O B. XXXVII.

To tell in the Latitude 90 (where the longest Day is six Months) how long it continues to be Twilight after Sun-set; and how long their Night is after Twilight ends, before it begins again.

R U L E.

YOU remember, according to the last Problem, the sun sets with the inhabitants at the N. pole, and rises to those of the S. pole, on September the 22d: consequently twilight begins with those at the N. pole on September the 22d. Therefore,

R U L E.

1. Elevate the N. pole to the Zenith, and turn the globe, till some degree of the sun's place in the ecliptic lies under 18° of the meridian, on the S. side of the Horizon, and you will find it 22° m; viz. November the 14th, the ending of twilight, that is, they have twilight from September the 22d, to November the 14th, and then they begin to have dark night (save the advantage of the moon) till the 28th of January. For,

2. Turn the globe till some other point of the ecliptic comes under 18° as before, and you will find it about 8° of ♊ , which answers to the 28th of January, the beginning of twilight to the inhabitants of the N. pole, and on March the 21st, the sun rises with them.

G 2

Thus

Thus it appears, that the length of their day (from sun-rising to sun-setting) is from March the 21st, to September the 22^d, viz. 185 days.* The length, or continuance, of twilight, is from September the 22^d, to November the 14th, and from January the 28th, to March the 21st, in all about 105 days; and their real night is from November the 14th, to January the 28th, viz. about 75 days.

Note, the same holds good (nearly) as to the inhabitants of the S. pole; for the sun rises with them when he enters $\sphericalangle$, and sets with them when he comes to ∇ .

Tyro. I perceive it plainly, Sir, and thank you for this clear demonstration.

Philo. Now, *Tyro*, I shall shew you the use of the celestial globe; and after that give you some Problems, with the practical use of both globes.

Here follow some Problems on the celestial globe.

P R O B. XXXVIII.

The Day of the Month being given, to find the Sun's Place in the Ecliptic.

See Problem VII.

P R O B. XXXIX.

This is the reverse of the last, and done the same way as Prob. VIII.

* It is an established maxim with many geographers, that all parts of the globe equally enjoy the benefit of the sun, in respect of time, and are equally deprived of it; but from hence it evidently appears that the North Pole is five of our days, every year, longer in the illuminated hemisphere than the South Pole.

PROB.

P R O B. XL.

To find the Declination of the Sun on any Day of the Year.

The same as Prob. X.

P R O B. XLI.

To find the Sun's right Ascension.

See Prob. XVII.

P R O B. XLII.

To tell the Sun's oblique Ascension and Descension in any Latitude, and on any Day.

The same as Prob. XVIII.

P R O B. XLIII.

The Latitude and Day being given, to find the Sun's ascensional Difference.

The same as Prob. XIX.

P R O B. XLIV.

The Latitude and Day of the Month being given, to tell the Sun's Amplitude; viz. his Distance from the E. and W. Points at rising and setting.

The same as Prob. XX.

P R O B. XLV.

The Latitude and Day being given, to tell the Sun's Azimuth.

The same as Prob. XXI.

P R O B. XLVI.

The Latitude, Azimuth, and Day being given, to tell the Hour of the Day.

See the rule, Prob. XXII.

P R O B. XLVII.

The Latitude, Day, and Hour being given, to tell the Sun's Almucantber.

See the rule, Prob. XXIII.

P R O B. XLVIII.

To find the right Ascension of any Star.

R U L E.

BRING the star to the meridian, and the degree of the equinoctial, cut by the meridian, is the right ascension required.

Thus you will find the right ascension of Aldebaran in Taurus to be about 66° , Arcturus in Bootes about $211^{\circ} 34'$, Regel in Orion about $76^{\circ} 8'$, and Sirius, or the Dog-star, about 99° , &c. &c.

P R O B. XLIX.

The Latitude being given, to tell the oblique Ascension and Descension of any Star.

R U L E.

RECTIFY the globe, and bring the star to the eastern verge of the Horizon, and the degree of the equinoctial, that is then cut by the

the

the Horizon, is the oblique ascension required. Turn the star to the western side, and the degree of the equinoctial, cut by the horizon at the setting of the star, is the oblique descension required.

Proceed thus, and you will find the oblique ascension of Regal to be about $86^{\circ} 54'$; of Marhal in Pegafus, about $325^{\circ} 13'$; and of Aldebaran, or the Bull's Eye, about $44^{\circ} 45'$. Turn each of these to the western side, you will find their oblique descension $65^{\circ} 22'$, 2° nearly, and $87^{\circ} 15'$.

Note, There is this difference between the right and oblique ascension and descension of the sun and stars, that the sun's oblique ascension, &c. differ every day in the same latitude; but the stars oblique ascension is every day the same.

P R O B. I.

To tell the Declination of the Stars.

R U L E.

AS for the sun's place, so also here, bring the given star to the Brazen Meridian, and observe what degree of the Meridian lies right over the star, for that is the declination either N. or S. according to which side of the equinoctial it lies on.

Thus you will find the declination of Aldebaran to be about $16^{\circ} 5' N.$ The upper Pointer to the pole (in Urfa Major) about $62^{\circ} 18'$, and the lower one $56^{\circ} 55'$, but Regal in Orion

I find about $8^{\circ} 27'$ S. and Cor Scorpionis about 26° S. declination, &c. &c.

From this Problem and the XLVIIIth arifeth

P R O B. LI.

The right Ascension and Declination of any Star being given, to find the Star at once.

BRING the given degree of right ascension on the equinoctial to the Brazen Meridian, then look under the degree of declination on the Meridian, and you will find the star at the Meridian, under the given degree of declination.

Thus, suppose I wanted to find Aldebaran, whose right ascension is 66° , and his declination $16^{\circ} 5'$ N. I first bring 66° of the equinoctial to the Meridian; and looking under $16^{\circ} 5'$ N. declination on the Meridian, I find Aldebaran.

So also Sirius has 99° right ascension, and $16^{\circ} 26'$ S. declination; therefore I bring 99° of the equinoctial to the Meridian, and looking under $16^{\circ} 26'$ S. declination on the Meridian, I find Sirius just at the Meridian. The same for any other star.

P R O B.

P R O B. LI.

To tell the rising and setting of the Stars, and the Point of the Compass any Star rises or sets upon in any Latitude, and on any Day of the Year.

R U L E.

BRING the sun's place to the Meridian, and rectify the globe; then turn the globe till the given star comes to the eastern verge of the Horizon, and the index of the hour circle will point to the time of rising, and the Horizon will shew the point it rises upon: turn it to the West, and the index will point to the time of setting, and the Horizon will shew you the point it sets upon.

Proceed thus, and you will find that Aldebaran, on November the 5th, at London, rises a little past 6 in the evening, and sets about 9 in the morning. The point he rises upon is E. N. E. and the point he sets upon is W. N. W. But Regel in Orion, the same night, rises a little before 9 at night, and sets about half past 7 in the morning. The point of rising is E. by S. and of setting W. by S.

Note, The stars rise and set every day on the same point of the compass, though at different hours.

P R O B. LIIL.

To tell the Time; viz. how many Hours any Star continues above the Horizon, from its rising to its setting, in any Latitude.

R U L E.

RECTIFY the globe, then bring the star to the eastern verge, and note the time of rising; then turn the globe to the western side, and the number of hours that the index passes over on the dial-plate tells you the continuance of that star above the Horizon.

Thus, I find Aldebaran at London continues up from the time of his rising on any day (but for example take December the 25th) about 15 hours, and Regal about $10\frac{1}{2}$ hours.

At Stockholm Aldebaran continues up above 16 hours; but at Port Royal he continues up but about $12\frac{3}{4}$ hours.

P R O B. LIV.

To tell the Distance of one Star from another, in Degrees and Minutes, in the Arch of a great Circle.

THIS Problem properly contains four questions, and therefore requires four answers.

I. If the stars lie under the same Meridian, but have different declinations, bring them to the Brazen Meridian, and the degrees intercepted between them, counted on the Meridian, is the distance required.

Thus,

Thus, I find, the two Pointers in the Great Bear to be about $5^{\circ} 30'$ distant from each other; and Eridef and the Dolphin's Eye about $29^{\circ} 30'$ distant.

2. If they have the same declination, but be under different meridians, bring the first (at pleasure) to the Brazen Meridian, and note the degree cut by the Equator; then bring the other to the Meridian, and note how many degrees have passed through the Meridian, for these shew their distance required.

Thus, I find, the difference between Affengue and Caput Medusæ to be about $122^{\circ} 30'$; for Affengue ($38\frac{1}{2}$ declination) being brought to the Meridian, cuts the Equator in $277^{\circ} 30'$, viz. $82^{\circ} 30'$ from γ westward; and Caput Medusæ cuts 40° of the Equator eastward; their distance, therefore, is $122^{\circ} 30'$.

3. If the stars neither lie under the same Meridian, nor have the same declination, then bring either of them to the Meridian, and elevate the pole to the same height as the star has declination (that is, the same as you elevate the terrestrial globe to the latitude of a place) for then the star will be in the Zenith; then fix the quadrant to the Zenith, over the given star, and extend it to the other star, and the degrees on the quadrant shew the distance required in a true arch of a great circle.

Note. Though the distance of the stars from each other is thus determined in degrees, yet you are not to suppose their distance is so many degrees to be converted into English miles; but it only means, that they appear so far distant under such an angle.

Thus, I find the distance between Capella and Cor Hydræ to be about 79° , and between Aldebaran and Sirius about $46^{\circ} 30'$, &c.

4. If the stars be at such a distance from each other, that the quadrant will not reach them, then bring either of them to the Horizon, and elevate, or depress the pole, till the other lies also at the verge of the Horizon, and the degrees counted upon the Horizon, between star and star, is their distance in degrees.

Thus, between Aldebaran and Cor Scorpionis you will find about 170 degrees.

P R O B. LV.

To tell what Stars will be on, or near the Meridian, at Noon and at Midnight.

First, for those at noon.

BRING the sun's place to the Meridian for the given day, and all those stars that are then under the Meridian are such as are full S. or N. at noon.

2. Turn the globe till the index points to 12 at night (viz. the lower 12) and all those stars that are then under the Meridian are the stars required.

Thus, I find, on May the 27th, Aldebaran is on the Meridian at noon, and Cor Hydræ will be on the Meridian August the 7th at noon; but on February the 4th, Cor Hydræ will be full S. about midnight. For only turn Cor Hydræ under the Meridian, and the index will
point

point to the lower 12; and the Meridian itself will cut the ecliptic in 16° of ♊ ; viz. February the 4th.

P R O B. LVI.

The Latitude, Day of the Month, and Hour of the Night, being given, to find the Altitude and Azimuth of a given Star.

R U L E.

RECTIFY the globe for the latitude, and day of the month, then set the hour index to the given hour, and move the quadrant of altitude to the given star; its Azimuth will then appear on the Horizon, and its altitude on the edge of the quadrant.

E X A M P L E.

Thus at London the 11th of May, at 11 o'clock at night, I find the altitude of *Cor Leonis* to be $26^{\circ} 50'$, and its Azimuth $76^{\circ} 30'$ from the South towards the W. or nearly West by South.

P R O B. LVII.

The Latitude, Day of the Month, and Altitude of a Star, being given, to find the Hour of the Night.

R U L E.

RECTIFY the globe for the given latitude, and day of the month, then turn the globe about in such a manner that the star may be upon
the

the edge of the quadrant in the given degree of altitude, then will the index point to the hour of the night.

This is but the converse of the former Problem, and therefore needs no example.

P R O B. LVIII.

To tell what Stars never rise, and those that never set, at London.

R U L E.

1. **O**NLY observe what stars have above $38^{\circ} 30'$ N. declination; for all such never set at London, but are always above the Horizon.

2. Observe also those stars that have above $38^{\circ} 30'$ S. declination, for those never rise, but are always under the Horizon at London.

Thus, the Pointers in the Great Bear, Arides in Cygnus, and many others, never set.

Also, Canobus in Argo Navis, and Pes Centauri, and many others, never rise at London.

OBSERVATION.

1. From what you have been taught, *Tyro*, it is easy to conceive, that by the inhabitants under the North pole no South star can ever be seen, nor can the inhabitants at the South pole ever see one of the stars in the other hemisphere. But,

2. The inhabitants under the Equator have a pleasant sight of all the stars from pole to pole; for they rise and set with them at right angles; therefore, no star can continue above 12 hours above their Horizon.

Tyro.

Tyro. Sir, you have highly obliged me, and I see now very plainly the different aspect of the heavens in different places.

P R O B. LIX.

To know at any Time of the Year (in the Latitude of London) where to find any Star, or tell the Name of any Star when required.

R U L E.

RECTIFY the globe for the day, and turn it till the index points to the given hour, then by a quadrant take the height of the required star; or, for want of it (in a common way of guessing) observe what part of the heavens it is in; viz. whether E. N. S. W. or the like, as also its height as near as you can guess: this being done, set the globe in due order for the day and hour, and you will find the same star on the globe: and, by applying the quadrant, you will find the exact point of the compass, and the real height the star then has, which, though not perhaps near to what you guessed them at, yet, if it be any noted star, you may assure yourself are its real height and bearing, as there is no other star of note near it about that height, and upon the same point.

E X A M P L E.

Walking on December 25, at 8 at night, I observed a bright star (as near as I could guess) on the S. E. point, and about 48° high;

high; I would know what star it is. Answer, Aldebaran. I rectify the globe, and turn the index to the hour, and then turn the quadrant to the given point of the compass, and looking about 48° high on the quadrant, I find Aldebaran to be the nearest bright star by the quadrant on that point and at that height; therefore, I conclude it is Aldebaran.

Also at $\frac{3}{4}$ past 10, the same night, I see two very bright stars, one on, or near the Meridian, about 30° high, and the other near the S. E. point, and about 35° high. I demand their names. Answer, Regel in Orion's Foot, and Procyon in Canicula.

P R O B. LX.

To tell the Latitude and Longitude of the Stars.

FIRST, observe, whether the given star be on the N. or S. side of the ecliptic; and if it be on the N. side, elevate the N. pole $66^{\circ} 30'$, and turn the globe till ♄ and ♅ lie in the N. and S. points of the Horizon, that is, till the ecliptic be parallel or even with the Horizon; fix the quadrant in the Zenith: then, keeping the globe steady, turn the quadrant till the edge of it touches the centre of the star, and that degree on the quadrant (viz. the altitude of the star in the latitude $66^{\circ} 30'$) is the latitude required, and the degree of the ecliptic, cut by the quadrant, reckoned from Aries (or

(or rather reckoned among the signs, as it happens) is the longitude required.

Thus you will find Arcturus in Bootes to be about $30^{\circ} 57'$ N. latitude, and $201^{\circ} 20'$ longitude from ϖ , or rather $21^{\circ} 20'$ of $\sphericalangle$. Also, Alcair is about $29^{\circ} 19'$ of N. latitude, and $28^{\circ} 51'$ of longitude in $\wp$.

2. For any South Star.

Elevate the S. pole $66^{\circ} 30'$, and fix the quadrant in the Zenith, and apply it to the star, as before directed, you have the latitude and longitude required. Thus you will find Pes Centauri to have about $42^{\circ} 28'$ of S. latitude, and 237° longitude from ϖ , or rather 27° in $\mathfrak{m}$, and thus for any other star. See Table IV. Dial. VII.

P R O B. LXI.

The Latitude and Day of the Month being given (suppose December 25, at nine at Night at London), to set the Globe so as to represent the Face of the Heavens at that Time, and shew your Acquaintance the Names and Positions of the most eminent fixed Stars.

R U L E.

RECTIFY the globe for the latitude, and bring the sun's place to the Meridian, and the index to 12. Then turn the globe to the given hour, viz. 9 at night, and there fix it, so will every star on the globe (if you set the globe N.

N. and S.) correspond with, or point to, the same star in the Heavens.

Thus (at London) I find Capella E. by S. about 75° high: Castor and Pollux, the first about 40° , and the latter about 45° high, near the E. point. Procyon below them, to the left hand, 23° high, E. S. E. Sirius yet lower, to the left, S. E. about 10° high; Betelgeuze on the same point, and about 38° high; Regel, more southward, about 26° high; Aldebaran, on the same point, much higher, viz. about 53° high; the Seven Stars, or Pleiades, S. nearly, about 62° high; Menkar, S. by W. 40° high; Arides, N. W. about 26° high, &c. &c. &c.

P R O B. LXII.

To tell the Time of the achronical rising and setting of the Stars.

DEFINITION.

1. **T**HE achronical rising of a star is when the star rises just at sun-set.
2. A star is said to set achronically, when it sets with the sun.

R U L E.

Bring the sun's place, for the given day, to the western side of the Horizon, and all those stars that are on, or near, the Eastern side of the Horizon, rise achronically; and those on the

the western verge of the Horizon set achronically.

Thus I find on December the 6th, that Aldebaran rises achronically, but it sets achronically on May the 21st. Also Sirius rises achronically on February the 4th, and sets achronically on May the 14th.

P R O B. LXIII.

To tell the cosmical rising and setting of the Stars in any Latitude.

DEFINITION.

A Star is said to rise cosmically, when it rises with the sun.

2. A star is said to set cosmically, when it sets at sun-rising.

R U L E.

Rectify the globe, &c. and bring the sun's place to the eastern side of the Horizon for the given day; then all those stars cut by the eastern verge of the Horizon rise cosmically. The globe still remaining in the same position, look at the western verge, or edge, of the Horizon, and all those stars cut by it, or that are very near it, set on that day cosmically.

Thus I find that Arcturus, and 2 small stars in Hercules's Thigh, rise cosmically, September the 25th. Also two stars in Eridanus, Affengue in Lyra, &c. &c. set cosmically. Marhal in Pegasus, is but just below the Horizon,

zon, therefore may be said to set nearly cosmical, as it will within a day or two.

For the cosmical setting.

Turn the globe till the star comes to the western side of the Horizon, and observe the degrees of the ecliptic, then cut by the eastern side of the Horizon, for that will answer to the day of the cosmical setting.

Thus Arcturus sets cosmically June the 22d. Also Aldebaran sets cosmically November the 25th.

P R O B. LXIV.

To tell the heliacal rising, or setting of the Stars.

DEFINITION.

1. **H**ELIACAL rising is when a star, once immersed in the sun's beams, gets out of them, so as to be seen at the eastern verge of the Horizon, just before sun-rising.

2. Heliacal setting, is when a star once out of the sun's beams gets into them so as to become invisible after sun-set.

Note 1. This heliacal rising and setting of the stars is different according to their different magnitudes. For,

Note 2. Stars of the first magnitude are seen at rising and setting when the sun is but 12° below the Horizon. Stars of the 2d magnitude are not perfectly seen, till the sun is 13° below the Horizon. Those of the 3d degree, when he is 14° . Those of the 4th degree of magni-

magnitude, when he is 15° below the Horizon. Those of the 5th degree, when he is 16° . Those of the 6th degree, when he is 17° ; and the nebulous, or small ones, not unless he is 18° below the Horizon; viz. about the beginning and ending of twilight.

To find the heliacal rising, the rule is, rectify the globe, and bring the given star to the eastern verge of the Horizon; then fix the globe, and turn the quadrant to the western side, till 12° of the quadrant touches the ecliptic; this done, note the degree of the ecliptic, that is cut by 12° of the quadrant on the western side (for then will the real place of the sun be depressed 12° on the eastern side) and that degree sought in the calendar gives the heliacal rising. The heliacal setting is found in the same manner by turning the quadrant to the eastern side. Thus you will find Aldebaran rises heliacally July the 4th, and sets heliacally May the 5th.

And Sirius the Dog Star rises heliacally about August the 26th.*

And

* N. B. The ancient poets make frequent mention of the stars rising and setting in these three ways, which, for that reason, are sometimes called *poetical*. The same poets likewise, and other writers, used to reckon their Dies Caniculares, or Dog Days, from the heliacal rising of Sirius; but they did not agree when they ended. Some reckoned them to continue 30 or 40, and others 50 days. However, in this they agreed, that the weather was very hot and sultry for 5 or 6 weeks after the rising of Sirius. But as it was then, so it is now a most ridiculous whim: for Sirius does not now rise heliacally till near September, though our almanack-makers
(for

And now, *Tyro*, I will leave you a few questions for practice at your leisure, in order to exercise you in the foregoing Problems.

P R O B. LXV.

The Latitude and Day given (suppose at London, November the 5th) to tell

1. **T**HE rising and setting of the sun, and the point he rises and sets upon.
2. His meridian altitude.
3. His altitude at any hour, suppose ten in the morning.
4. His right and oblique ascension.
5. His ascensional difference.
6. His amplitude at rising.
7. His Azimuth at 10 in the morning.
8. His Almucanter at the same time.
9. The time he is due E. *
10. The length of day and night.
11. The length of twilight.
12. The length of the real night.
13. The people to whom he will be vertical that day.

(for what reason I know not) continue to reckon the beginning of Dog Days from July the 30th. But, however, it is plain that Sirius can no ways be charged with bringing this sultry weather; because three or four thousand years hence he will not rise heliacally till November, and then, perhaps, will be charged with bringing as much cold as he has hitherto been accused of bringing heat.

* To find what time the Sun will be due east when he is below the Horizon, find the time when his opposite place will be due west, and *vice versa*.

14. The

14. The very place to which he will be vertical at 10 o'clock at night at London.
Also,
15. To tell what time Aldebaran, or any other star, will rise and set that night.
16. To tell also what time any star will be due E. or W. (suppose Aldebaran) what is its amplitude at rising and setting, its Azimuth at 8 at night, and the time of its being full S. Also,
17. To tell what point of the compass the Pointers will then be on, and what time they will be on the meridian above and under the pole star.

Tyro. You may depend, Sir, upon my trying to work these Problems the first opportunity.

Philo. Very well; since you delight in these things, I will not leave you yet, but will shew you some Problems relating to Navigation and spherical Triangles, &c.

S E C T. II.

Containing some useful Problems in Navigation.

P R O B. I.

The Sun's Declination and Hour, when he is due E. being given, to find the Latitude, viz. the Elevation of the Pole.

R U L E.

RECTIFY the globe to the same latitude as the given number of degrees of declination,
and

and fix the quadrant in the Zenith; then convert the hours that the sun is due E. before, or after, 6 o'clock, into degrees, and count the same number of degrees on the Horizon, from the E. point southwards, and bring the quadrant to that degree of the Horizon, so shall the degree on the quadrant that is cut by the Equator be the complement of latitude, which taken from 90° , gives the latitude itself, or height of the pole.

E X A M P L E.

Sailing May the 21st, I made an observation that the sun was due E. about 7 minutes past 7 in the morning, and his declination 20° N. I demand what latitude I was in.

Proceed by the rule, you will find the latitude to be $51^\circ 30'$ nearly.

P R O B. II.

Having the Sun's Azimuth at 6 o'Clock, and Declination, to find the Latitude.

R U L E.

AS many degrees as are contained in the Azimuth given, so much elevate the pole, and fix the quadrant in the Zenith, and bring γ to the meridian: this done, count on the quadrant upwards, the complement of the sun's declination to 90° , and bring that degree to the Equator, then the degree of the Horizon,

cut

cut by the quadrant, will be the complement of latitude, counted from the E. point, or else from the W. as it may happen, and what this sum wants of 90° is the latitude required; or otherwise, the degrees counted from the other two cardinal points, either N. or S. as it may happen, will give the latitude.

E X A M P L E.

I find the sun's Azimuth, at six o'clock, to be $12^\circ 46'$ m. and his declination 20° d. what is the latitude? Work according to the rule, and you will have the answer $38^\circ 30'$ complement, that is $51^\circ 30'$ latitude required.

P R O B. III.

The Sun's Amplitude and ascensional Difference being given, to find the Elevation of the Pole, and Sun's Declination.

R U L E.

RAISE, or elevate the pole so many degrees as is the ascensional difference, fix the quadrant in the Zenith, bring γ to the meridian, then count on the quadrant upward the complement of amplitude, and move the quadrant, till the same number on the quadrant cuts the Equator; the quadrant will then cut the Horizon in the degree of the pole's elevation, and the Equator in the degree of declination.

H

EX-

E X A M P L E

I made an observation, that the sun's ascensional difference was $27^{\circ} 30'$, and his amplitude $33^{\circ} 38'$; I demand the latitude and declination.

Proceed according to the rule, and you will find the latitude $51^{\circ} 30'$, and the declination $20^{\circ} 10'$.

P R O B. IV.

The Sun's Altitude E. and his Declination being given, to prove the Elevation of the Pole.

R U L E.

ELEVATE the pole to the complement of the sun's altitude at E. and fix the quadrant in the Zenith, and bring γ to the Meridian, then note on the quadrant of altitude the degree of declination, and bringing the same to the Equator, observe what degree the quadrant cuts the Equator in; for its complement to 90° is the height of the pole.

E X A M P L E.

The sun's declination being $20^{\circ} 10'$ N. his altitude E. (at London) $26^{\circ} 8'$, I would know whether the supposed latitude ($51^{\frac{1}{2}}$) agrees herewith in operation?

Here I subtract $26^{\circ} 8'$ from 90° , and there remains $63^{\circ} 52'$ complement of altitude, and I elevate

vate the pole accordingly, &c. Then I bring ϖ to the meridian, and cause $20^{\circ} 10'$ on the quadrant to cut the Equator, and find it $38^{\circ} 30'$, the complement of latitude required; which subtracted from 90° , gives $51^{\circ} 30'$, the real latitude of the place.

P R O B. V.

*The Sun's Declination and Amplitude being given,
to find the Height of the Pole.*

R U L E.

ELEVATE the pole to the complement of amplitude, and fix the quadrant in the Zenith, and bring ϖ to the meridian, then count the sun's declination on the quadrant, and bring that degree to the Equator; and the degree of the Equator, cut by the quadrant, is the height of the Pole, or the latitude required.

E X A M P L E.

Suppose the Sun's amplitude $33^{\circ} 38'$, and his declination $20^{\circ} 10'$, what is the latitude?

Proceed according to the rule, and you will find it about $51^{\circ} 30'$.

Tyro. I heartily thank you, Sir.

Philo. There are many other questions relating to Navigation, which may be deduced from these, and performed on the globes; which you will find treated of by and by.

S E C T. III.

Containing some practical Problems, relating to spherical Triangles, applied in some measure to Navigation, Dialling, &c. by which the Learner will see more of the Nature of the Doctrine of the Sphere, than he possibly can do by way of Plane.

Note 1. That every triangle has three sides and three angles.

2. The Perpendicular (called also Cathetus) shall be here represented by, or placed on, the Brazen Meridian itself.

3. The base shall be placed in general upon the Equator.

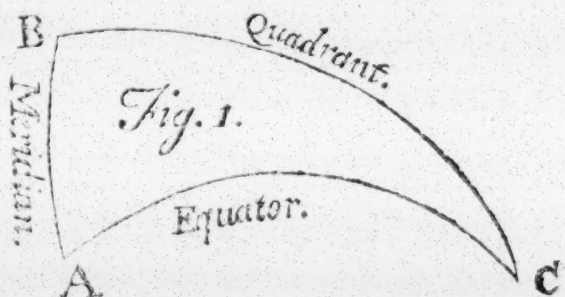
4. The Hypothenuſe (or diagonal line) is represented by the quadrant fixed to the Zenith, and turned to the extremities of the Perpendicular and Base, which will form a complete right-angled triangle.

5. A right-angled triangle is ſuch as has one of the angles right, or that contains 90° . An acute angle is leſs than 90° , and an obtuſe angle is more than 90° , as you will ſee by Prob. V.

PROB.

P R O B. I.

In the right-angled spherical Triangle ABC, let the Perpendicular AB be $42^{\circ} 30'$, the Base AC $60^{\circ} 15'$; I demand the Hypothenufe BC.



BRING γ to the Brazen Meridian, and there fasten the globe: then count from Aries $42^{\circ} 30'$ on the Brazen Meridian, which is the perpendicular, and at $42^{\circ} 30'$ fix the quadrant of altitude. Then count from Aries on the Equator $60^{\circ} 15'$, which will represent the base; and note well the degree on the Equator, or else make a small dot. This done, turn the quadrant till the figured edge of it touches the Equator at $60^{\circ} 15'$; and the degrees on the quadrant from the Equator to the Zenith will be the Hypothenufe required, viz. about $68^{\circ} 15'$.

Note. It matters not in these sort of Problems whether you elevate the pole to the number of degrees of the perpendicular; for the answer will be the same whether you do so, or not.

Thus you will find also, when the Perpendicular is $55^{\circ} 45'$, and the Base $70^{\circ} 30'$, the Hypothenufe will be $79^{\circ} 30'$ nearly.

H 3

P R O B.

P R O B. II.

The Base AC $60^{\circ} 15'$, and Hypothenuſe BC $68^{\circ} 15'$ given, to find the Perpendicular AB.

R U L E.

COUNT from Aries on the Equator the baſe AC, and let the quadrant be on the Meridian, without being fixed faſt, ſo that you may flip it backward and forward, till $68^{\circ} 15'$ of it (which is the Hypothenuſe BC) juſt touches $60^{\circ} 15'$ on the Equator; for then will the Meridian, from Aries to the nut of the quadrant, tell you the perpendicular AB, viz. $42^{\circ} 30'$. See the figure. Alſo, let the baſe AC be $66^{\circ} 30'$, and the Hypothenuſe BC be 75° , AB the perpendicular will be $49^{\circ} 32'$.

P R O B. III.

The Perpendicular AB $42^{\circ} 30'$, Hypothenuſe BC $68^{\circ} 15'$ given, to find the Baſe AC.

R U L E.

COUNT from Aries on the Meridian $42^{\circ} 30'$ the perpendicular AB, and there fix the quadrant; then turn the quadrant till $68^{\circ} 15'$, on the quadrant from the Zenith, touches the Equator, and the degrees on the Equator intercepted between the point Aries, and the quadrant, ſhew you the baſe AC; viz. $60^{\circ} 15'$. See the figure. Alſo, let the perpendicular AB be 35° , and the Hypothenuſe BC be $81^{\circ} 30'$, AC the baſe will be $79^{\circ} 36'$.

Tyro.

Tyro. I understand the operations quite well.

Philo. I am glad of it; and it pleases me much to see you can apply things so well; for, you may observe, the Meridian cuts the Horizon, as well as the Equator, at right angles; therefore, by counting the Perpendicular from the Horizon on the Meridian, the quadrant will still be the Hypothenuse, and will cut the Horizon at the extremity, or degree, of the Base, as it did the Equator before.

From hence arise the following observations.

OBSERVATION I.

The N. and S. points of the Brazen Meridian being 180° distant, it is plain that the quadrant of altitude fixed in the Zenith will (however extended) make two angles equal to 180° , or half the circle. For instance, if I lay the quadrant from the Zenith to the E. or W. points, I then have two right angles, each equal to 90° , viz. together equal to 180° ; and if I move the quadrant from these points, suppose 30° , to the N. or the S. I still have two angles made by the quadrant, the Meridian and Horizon equal to 180° : viz. one of them equal to 120° , and the other equal to 60° .

OBSERVATION II.

From hence then it plainly appears, that you may (by a little attention) find the length of any side, or the angle formed by any two sides of a triangle; viz. whether it be an acute an-

gle (viz. less than 90°) or an obtuse angle (viz. more than 90°).

Tyro. I am still more highly obliged to you, Sir, for this clear demonstration.

Philos. I shall then leave it wholly to your own consideration and practice, as it is so plain and obvious, and proceed to an useful application of Prob. I.

P R O B. IV.

A Ship sails from N. Latitude $55^\circ 45'$ in a direct Course, till she comes to the Equator, and her Difference of Longitude is $76^\circ 30'$ E. from the Place whence she departed: I demand the Rhumb in Navigation she is then upon, and the Distance from the Place she sailed from, allowing 60 Miles to a Degree, and her Distance in an Arch of a great Circle, viz. $69\frac{1}{2}$ Miles to a Degree?

A N S W E R.

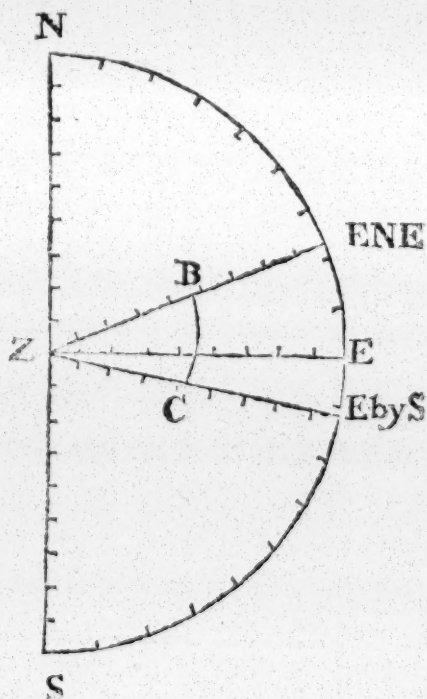
THE rhumb the ship is upon is EbS. The distance from the place she sailed from is 82 degrees, that is, 4920 miles, at 60 to a degree, or 5699 miles, at $69\frac{1}{2}$ to a degree.

PROB.

P R O B. V.

Two Ships, B and C, set sail from Z, in Latitude 32° N. and Longitude $62^{\circ} 30'$ W. from London. B goes ENE. $46^{\circ} 30'$, and C sails E. by S. $43^{\circ} 30'$; I demand,

1. From whence they sail.
2. The Places they arrive at.
3. The Rhumb, from the N. each Ship sailed upon
4. The Angle they make at setting out.
5. Their Difference of Longitude from the Place they set out.
6. Their Distance and Situation from each other.



1. **R**ECTIFY the globe to the given latitude and longitude, and Bermuda will be found to be the place they sailed from.

H 5

2. Place

2. Place the quadrant in the E. N. E. point, count from the Zenith on the quadrant $46^{\circ} 30'$, which will give the place where the ship B is, viz. Gibraltar. Again, turn the quadrant to the E. by S. point, and count from the Zenith $43^{\circ} 30'$, where you will find the place that the ship C arrived at, viz. Cape Verd.

3. Count the points from the N. and B will be found to have sailed on rhumb 6, and C on rhumb 9.

4. The degrees on the Horizon from the E. N. E. to the E. by S. will shew the angle they made at setting out, viz. $33^{\circ} 45'$.

5. Bring the place each ship arrived at to the meridian separately, it will shew you the difference of their meridian from the first setting out; viz. B $57^{\circ} 30'$, C $45^{\circ} 30'$, both eastward. Their difference of longitude is 12° .

6. For their distance, bring either of the places arrived at, suppose Gibraltar, to the meridian, elevate the pole, and fix the quadrant in the Zenith; extend it to Cape Verd, and you will find it 24° S. W. by S. which, multiplied by 60, gives 1440 miles.

Philo. I shall now shew you how to make a common dial, from whence you will naturally see the properties of the sphere more plainly, and by the interfection of the different circles, will yourself be able to raise many curious and useful Problems.

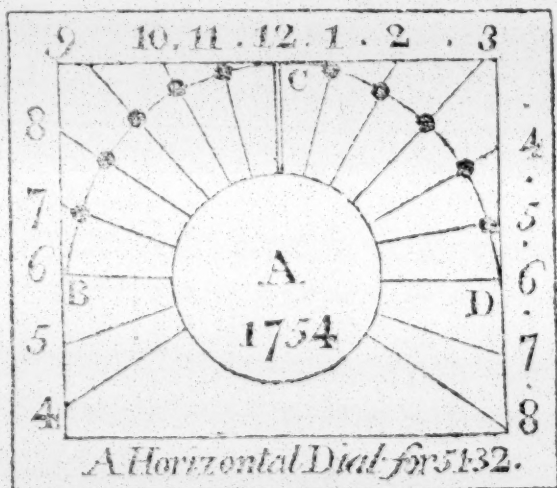
P R O B. VI.

To make an horizontal Dial (*viz.* a Dial to be set upon a Post, or Pedestal) in any Latitude; but suppose for London.

E X A M P L E.

LET it be required to make an horizontal dial for the latitude of London.

First, Take a piece of brass, or a thick smooth painted piece of board, of the same size as that of which you would have your dial;



and describe upon it, a semicircle at pleasure from the centre A, as B, C, D.

Secondly, Divide this semicircle into two equal parts by the line A 12.

Thirdly, Draw right lines by the extremity of the semicircle, so as to make them tangents to it at B, C, and D; these are to contain the hour lines; and thus is your plane, or dial-plate, ready to have the hours drawn from the centre.

H 6

Now

Now to find the distance from the meridian, or 12 o'clock line, in degrees and minutes.

R U L E I. is,

Bring the vernal colure (viz. γ) to the meridian, and the index to the upper 12; this done, turn the globe westward, till the index points to one o'clock; (or till 15 degrees pass through the meridian) and you will find the colure (viz. the line that passes through Aries from pole to pole) to cut the Horizon in $11^{\circ} 50'$ from the meridian, the distance from the 12 o'clock line to 1, or 11, which set off by any scale of chords from the meridian 12 on the semicircle.

Secondly, Turn the globe till the index points to 2, and the colure will cut the Horizon in $24^{\circ} 15'$, the distance from 12 to 2 or 10: turn the globe till the index points to 3, and the colure will cut the Horizon from the Meridian in about $38^{\circ} 5'$, the distance from the Meridian to 3 or 9: turn it till the index points to 4, and the colure will cut the Horizon in $53^{\circ} 30'$, the distance from 12 to 4 or 8. Turn it till the index points to 5, and the colure will cut the Horizon in $71^{\circ} 4'$, the distance from the Meridian, or 12 o'clock line, to 5 or to 7. The six o'clock line will be 90° from the Meridian, or 12 o'clock line, or will fall into the arch CD in the point D, viz. the colure will cut the Horizon at 90° , or in the east point.

Thirdly, Take off these degrees and minutes from any sector or scale of chords: and setting
one

one foot of the compass in C, set off on the circle from C towards B and D $11^{\circ} 50'$, $24^{\circ} 15'$, &c. &c.

Fourthly, From the centre A draw lines through these dots or pricks, to the tangents or lines without the semicircle, and you have the true hour lines.

Note 1. The halves and quarters are found the same way, by turning the globe till the index points to $\frac{1}{2}$ past 12; $\frac{1}{2}$ past 1, &c. and observing in how many degrees the colure cuts the Horizon from the Meridian.

Note 2. After you have drawn the hours from 12 to 6 in the morning, and six in the evening, you may easily get the hours at 5 and 4 in the morning, by laying a ruler from the hours of 5 and 4 in the afternoon, and drawing lines through the centre. The same may be done on the other side of the plane, that is, lines drawn from 7 and 8 in the morning, will be 7 and 8 at night.

Note 3. The style or gnomon of this dial makes an angle with the 12 o'clock hour line of $51^{\circ} 32'$, and must be put in the centre A, and stand directly over the 12 o'clock line, or meridian of the plane.

 *Note*, Always remember to make an allowance for the thickness of the style or gnomon on the plane, by drawing two lines by the side of the Meridian line, as wide as the style is thick.

P R O B. VII.

To make a direct S. Dial. in the Latitude of London.

There are two ways.

FIRST, let the globe remain for the latitude of London as before, and fix the quadrant in the Zenith, and turn it to the E. point, or
to

to the W. and there fix it: then turn the globe to 11 o'clock or to one, and the colure will cut the quadrant in $9^{\circ} 30'$.

Turn it to 10 or 2, the colure will cut the quadrant in $19^{\circ} 45'$, the distance from the Meridian.

Turn it to 9 or 3, it cuts the quadrant in $31^{\circ} 53'$.

Turn it to 8 and 4, it cuts in $47^{\circ} 8'$.

Turn it to 7 and 5, it cuts it in $66^{\circ} 42'$.

Or,

2. Elevate the pole to the complement of London's latitude to 90, viz. to $38\frac{1}{2}$ (for $38\frac{1}{2}$ and $51\frac{1}{2}$ make 90) then turn the globe till the index points to 11 or 1, and the colure will cut the Horizon in $9^{\circ} 30'$; turn it to 10 or 2, the colure will cut the Horizon in $19^{\circ} 45'$, &c. as before.

Tyro. Sir, I am extremely obliged to you; but if it were not too much trouble, I would take it as a favour if you would give me one example how to make a vertical dial that declines from the S. either eastward or westward; for you know that it is a chance indeed that a wall should exactly face the south.

Philo. I am ready to do every thing, *Tyro*, that lies within the compass of time, room, and ability. We will suppose then it were required as follows; viz.

PROB.

P R O B. VIII.

To make an erect, or vertical Dial, declining from the North towards the East or West.

E X A M P L E.

Let it be a Dial declining from the N. eastward 60° .

R U L E.

1. **R**ECTIFY the globe, quadrant, colure, and index, as before.

2. Bring the quadrant of altitude to cut the Horizon in the degree of declination; viz. 60° from the N. point, eastward, which represents a plane, declining that number of degrees.

3. Hold the quadrant fast at 60° , and turn the globe eastward, till the index points to all the forenoon hours, and the colure will cut the quadrant in the number of degrees each hour is distant from the Meridian; and lines drawn through each of these from the centre, are the hours required.

Thus to find the forenoon hours.

I turn the globe till the index points to 11, 10, 9, &c. or till 15° of the Equator pass through the Meridian, and I find the colure cuts the quadrant (from the Zenith) as follows.

11	o'clock	9°	30'
10	————	18	15
9	————	26	12
8	————	35	5
7	————	45	10
6	————	57	20
5	————	76	00

The

The forenoon hours required, which will be on the W. or left-hand side of the 12 o'clock line, because the plane declines eastward, and consequently you have more hours in the forenoon than in the afternoon on this plane.

2. *To find the afternoon hours.*

I now turn the quadrant to the opposite point of the Horizon; viz. I cause it to touch 60° of the Horizon from the S. towards the W. and bring the index and colure back to the Meridian.

Then turning the globe westward, till the index points to 1, 2, 3, and 4, or till 15° pass through the Meridian, the colure will cut the quadrant (counted from the Zenith) as follows.

For 1	o'clock	12°	45'
2	————	29	45
3	————	52	45
4	————	80	15

These are the distances of the afternoon hours, from the 12 o'clock hour or meridian. Here you see the colure goes off the quadrant; therefore the sun goes off this plane about 4.

3. *To find the distance of the Substyle, or place of the gnomon from the 12 o'clock line, as also the height of the style; do thus:*

Bring the colure to the Horizon in the plane's declination, counted from the S. towards the E. viz. bring the colure to 60° in the Horizon,
counted

counted from the S. eastward; and then turn the quadrant till that touches the same number of degrees (viz. 60°) from the N. eastward; so shall the quadrant and colure cut each other at right angles; and the number of degrees counted on the quadrant from the colure to the Zenith are the degrees of the substyle's distance, viz. $21^{\circ} 40'$; and the degrees from the pole to where the quadrant cuts the colure, counted on the colure, is the height of the style, viz. $32^{\circ} 45'$.

Lastly, Measure or take off $21^{\circ} 40'$ from any scale of chords, and setting one foot at the 12 o'clock line, turn the other westward, or to the left hand, and make a dot or prick; for right over this dot must the substyle or gnomon stand.

And thus by a little attention may any sort of declining, inclining, or reclining dials be easily made by the globe. For a direct S. dial at London will be an horizontal dial to the inhabitants of $38^{\circ} 28'$ S. latitude; viz. 90° distance from our Zenith.

So an erect plane under the pole is an horizontal one under the equator. An erect vertical at 80° N. latitude, will be a horizontal in 10° S. latitude, &c. &c.

Tyro. Sir, I heartily thank you; for this gives me a clearer notion of the position of places and planes than I had before. But, pray, may not some problems relating to the moon be performed by the globes?

Philo. Yes; the very same way as those relating to the sun, when once you know her place in the ecliptic; but this you must find
very

very often, because it is continually changing, and indeed is so variable, that the operation will not stand long, or hold good but for that day only: but by getting her true place, you may tell her rising, setting, and southing, the hour of the night, the time of high water, &c. &c.

I will give you a small notion of it, and leave the rest to exercise your own ingenuity. Divide the equinoctial into 30 equal parts, by red strokes or figures, beginning at Aries, and at every 12th degree making a mark, as 1, 2, 3, 4, &c. this represents the 30 days of her age.

Now to find her place. Elevate the N. pole to the Zenith, and bring the equinoctial colure against the day of the month on the Horizon, viz. the day of new moon, so shall the moon's age (wrote in red figures) on the equinoctial, point to the degree of the Ecliptic, on the Horizon, she is in, or near, at that time.

Tyro. I am extremely obliged to you, Sir, for all these favours; but, as necessity obliges me to go, I beg you would excuse me, and receive my hearty thanks.

Philo. My dear pupil, I wish you well, and would advise you to employ your time in the practice of these things, rather than spend it in trifles and idleness.

Tyro. Sir, I thank you for your good advice, and am your humble servant.

Philo. Farewell.

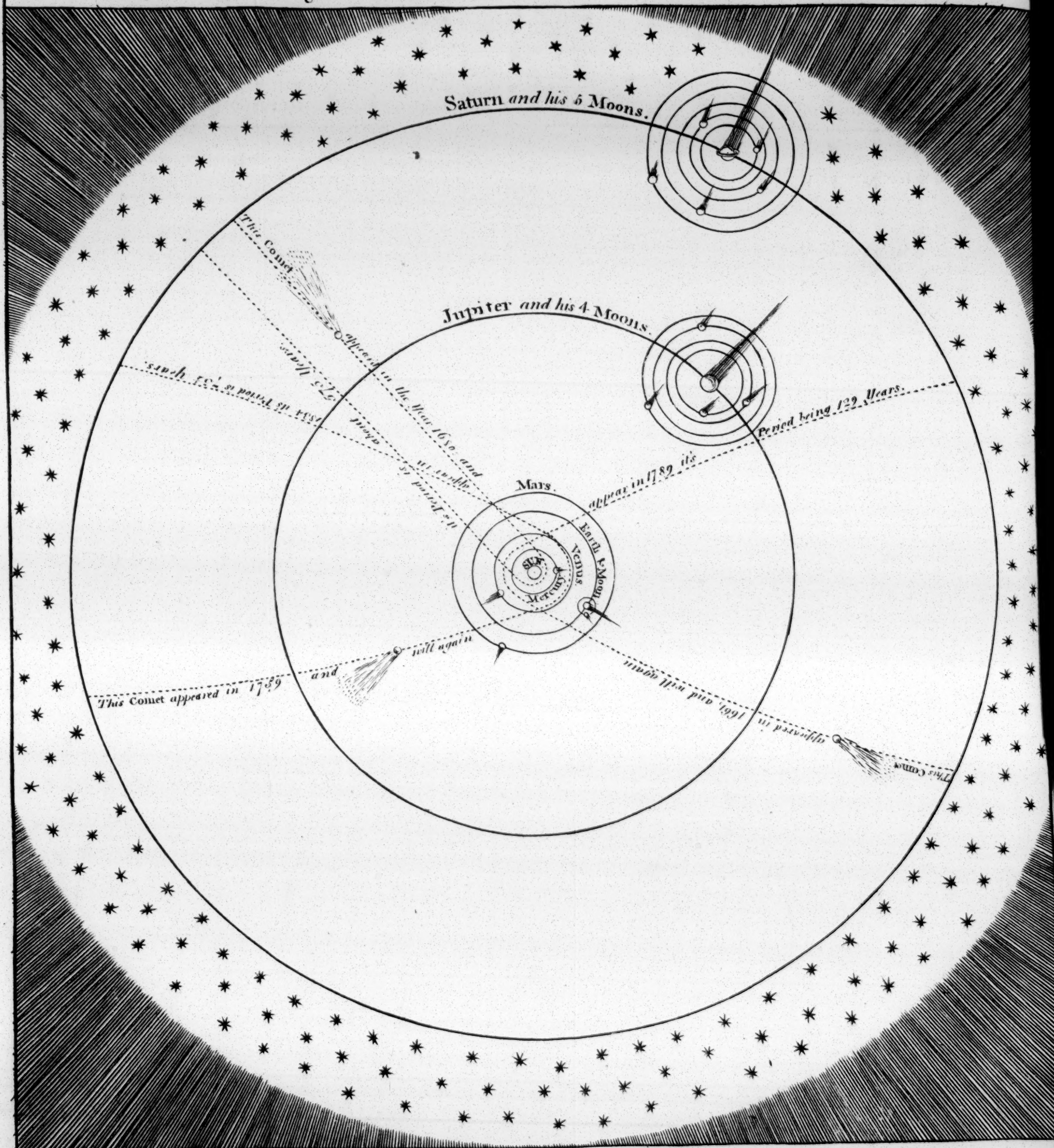
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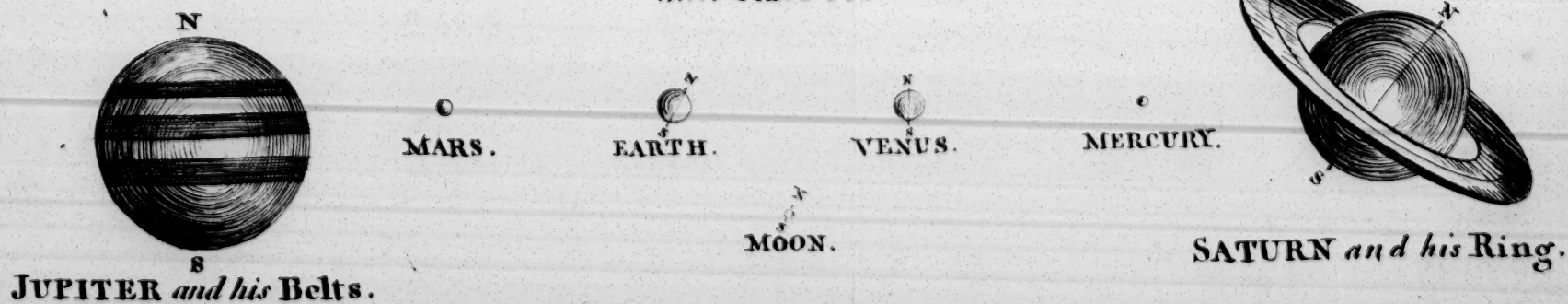
The COPERNICAN or TRUE SYSTEM of the UNIVERSE

exhibiting the Orbits of the PLANETS according to their mean Distances from the SUN

Engrav'd According to Act of Parliament for M^D.FENNING's, New Use of the Globes.



The PLANETS in Proportion to each other with the Inclinations of their Axes &c.



Note: The Sun is about 10 inches in Diameter, according to the above Proportion of the Planets.

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A P P E N D I X:

CONTAINING

A short Account of the Solar System, and
of the Comets, and fixed Stars.

D I A L O G U E

*Between PHILO, a Tutor, and TYRO, a Pupil,
concerning the Solar System.*

Tyro. **T**HOUGH you have given me some notion of astronomy in the several problems you have solved relative to the sun and stars, yet, as I have heard many things concerning the solar system, and the comets and fixed stars, which I do not understand, I would take it as a particular favour if you would give me a more full and circumstantial account of these heavenly bodies.

Philo. I will, my dear Tyro; but you must be content with a short account indeed: for to give you a full account of all these particulars would greatly exceed the limits of this little Treatise, and still more, the bounds to which

which I am confined in this short Appendix. By the solar system, then, you are to understand the sun, which is placed in the centre, together with the six planets, Mercury, Venus, the Earth, Mars, Jupiter, and Saturn, which move round him. These planets, with respect to their nearness to the sun, are exactly in the order in which they are here mentioned. Mercury is nearest to the sun, Venus next, the Earth next, Mars next, Jupiter next, and Saturn is at the greatest distance of all. The distances of the planets from the sun may easily be conceived in the following manner: supposing the distance of the earth from the sun to be divided into 10 equal parts, then that of Mercury will be four of these parts; that of Venus 7; that of Mars 15; that of Jupiter 52; and that of Saturn 95. Hence it appears, that the Earth is placed between Mars and Venus, having Mars, Jupiter, and Saturn above her, and Venus and Mercury below her; and for this reason it is, that the three first are called superior, and the two last inferior planets. But to express the distances of the planets from the sun as nearly as possible, in English miles, the distance of Mercury from it is 36,841,468 miles; of Venus, 68,891,486 miles; of the Earth, 95,173,000 miles; of Mars, 145,014,148 m.; of Jupiter, 494,990,976 m. and of Saturn, 907,956,130 m. By these distances, however, are to be understood their mean distances; in order to comprehend which, it must be observed, that the orbit, or path, which

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which a planet describes about the sun, is not a perfect circle, but a figure called an ellipsis; which, though somewhat resembling a circle, is longer than it is broad. Hence the same planet is not always at the same distance from the sun, and the mean distance of it is that which is exactly between its greatest and least distance. The planets appear at first sight like the fixed stars; but, upon a more accurate view, they may easily be distinguished from them. 1. By their never twinkling, as these last do. 2. By their being seen earliest in the evening, and latest in the morning. And 3. By their changing their position with regard to the fixed stars, and to one another; but always keeping within the zodiac, that is, within 8 degrees of the ecliptic, either south or north. Mercury is so near the sun, that he can seldom be seen without the help of glasses. Venus is easily known, being sometimes the evening, and sometimes the morning star; and Mars, Jupiter, and Saturn appear of a more red or fiery colour than the fixed stars.

Tyro. Do all these planets perform their revolutions round the sun in the same time?

Philo. No; that is not likely, considering their different distances from him. Mercury performs his revolution in about three months; Venus in about seven months and a half; the Earth in a year; Mars in about two years; Jupiter in twelve, and Saturn in about thirty years.

Tyro.

Tyro. Are all the planets of the same bulk or magnitude?

Philo. No: the Earth is 27 times as big as Mercury, very little bigger than Venus, 5 times as big as Mars; but Jupiter is 1049 times as big as the Earth, Saturn 586 times as big, exclusive of his ring; and the sun is 877,650 times as big as the earth.

Tyro. You say the earth moves round the sun. How can I believe that, when I plainly see, that the sun moves round the earth?

Philo. You must naturally think so; but you are mistaken; and your mistake is easily accounted for from the following circumstance, namely, that the appearance will be the same to you, whether the sun moves round the earth, or the earth round the sun. But first I must observe, that the earth has two motions; one round its own axis from west to east, in twenty-four hours, which makes all the heavenly bodies appear to move round the earth from east to west in the same time, and causes the regular succession of day and night; and the other round the sun in the space of a year, which occasions the change of the seasons. That the appearance will be the same if the earth turns round its axis, as if all the heavenly bodies moved round the earth, may be easily proved by a very simple experiment. Go on board a ship, and let her be turned gently and uniformly round, you will not be sensible of the ship's motion, but will imagine that all the objects on land are moving round the ship. In like man-

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ner, let one ship be fixed immoveably in her station; go on board another ship at the distance of two or three miles: let this second ship sail regularly and uniformly in a circular direction round the first ship; you will not be sensible of the motion of the ship in which you are, but will imagine that the immoveable ship is moving round you. The first of these is an exact representation of the diurnal motion of the earth round its own axis; the second, of its annual motion round the sun.

Tyro. But though these motions of the earth be perfectly reconcileable to appearances, it does not therefore follow, that they take place in fact.

Philo. That they do take place in fact, astronomers have proved by a variety of arguments, many of which are above your comprehension; and besides, to mention them all, or even the principal of them, would greatly exceed the limits of this short Appendix: I shall content myself at present with taking notice of one or two. In the first place, if the earth does not turn round its own axis, the sun and stars must move round the earth in the space of 24 hours. But considering the great distance of the sun from us, if he was to go round the earth in 24 hours, he must travel upwards of 300,000 miles in a minute; and as the stars are at least 400,000 times as far from the sun as the sun is from us, those about the Equator must move 400,000 times as quick as the sun. But this is a degree of velocity, which it exceeds the
utmost

utmost stretch of human imagination to conceive; and indeed it seems to be as impossible to form any idea of it, as of infinite space, or eternal duration. It is, therefore, natural to conclude, that the earth turns round its axis, which is easily conceived, instead of the sun and stars moving round the earth, which it is impossible to comprehend.

In the next place, it is an established law of nature, that a heavy body never moves round a light one as its centre of motion. A pebble, fastened to a mill-stone by a string, may by an easy impulse be made to circulate round the mill-stone; but no impulse can make a mill-stone circulate round a loose pebble, for the heaviest would undoubtedly carry the lightest along with it wherever it goes. But the sun is at least 227 thousand times as heavy as the earth; and therefore, instead of the sun moving round the earth, not only the earth, but all the other planets, must move round the sun as their centre of motion. Besides, if the sun moved round the earth, it would take no less than 173,510 days to perform its revolution, and in that case our year would be 475 times as long as it now is; but as we find the regular return of the seasons, that is the completion of a whole year in 365 days and about 6 hours, in necessarily follows, that the earth must move round the sun. Add to this, that, as the other planets, in their revolutions round the sun, sometimes move forward, sometimes seem to stand still, and sometimes to move backward, all these irregularities

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are easily accounted for by supposing the earth to move round the sun, but cannot be explained on the contrary supposition, of the sun's moving round the earth.

Tyro. I beg leave, Sir, to mention one objection to the diurnal rotation of the earth on its own axis. If it moves, as you say, from west to east, will not a ball, fired perpendicularly upward in the air, fall considerably westward of the place from which it was shot?

Philo. By no means: for as both the gun and ball partake of the earth's motion, the ball will be carried forward with the air as quick as the earth and air turn, and will therefore fall on the very spot from which it was fired. Thus, if you let fall a stone from the top of a main-mast, it will fall on the deck as near the foot of the mast when the ship sails as when she is at rest.

Tyro. Do the other planets, as well as the earth, turn round their axes?

Philo. Some of them do. Venus turns round her axis in 24 days, 8 hours; Mars in 24 hours, 40 minutes; and Jupiter in nine hours, 56 minutes. Whether Mercury and Saturn have any revolution round their axes is not yet known. The sun turns round his axis in 25 days, 6 hours; and the moon round hers in 29 days, 12 hours, and 44 minutes; that is, in the same time that she revolves round the earth, so that she has always the same face turned towards the earth.

Tyro. Is not the moon one of the planets?

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Philo.

Philo. She is; though not a primary, but only a secondary planet, or satellite; that is, an attendant upon the earth, about which she revolves as her centre of motion, in the same manner as the earth revolves round the sun from west to east; and hence it is, that she rises every night considerably later than she did the preceding one, except during harvest, when, for several nights together, she rises, when at full, nearly at the same time; for which reason this moon is, by way of distinction, called the harvest moon. When the moon is directly between the earth and the sun, it causes an eclipse of the sun; and when the earth is directly between the sun and the moon, it causes an eclipse of the moon. The former always happens at new moon; the latter at full moon. But neither of them happen at every new and full moon; for, if they did, there would be twelve eclipses of each luminary in the course of a year, whereas there are never more than seven, nor less than two.

Tyro. Have the other planets any moons?

Philo. Jupiter has four moons, and Saturn five. Mercury, Venus, and Mars, have no moons; at least none that have yet been discovered. Saturn has, besides, a thin, broad ring (which I mentioned above) that surrounds his body, without touching it, in the same manner as a horizon does an artificial globe. It is 21,000 miles in breadth, and is as far from Saturn on every side.

Tyro.

Tyro. Is the moon as big as the sun, as she appears to be?

Philo. So far from it, that she is, at least, 42,875,000 times less than the sun. The reason of her appearing as big as the sun is, that she is much nearer the earth. Her distance from the earth is only 240,000 miles, whereas that of the sun is 95 millions.

Tyro. What kind of bodies are the planets?

Philo. They are dark or opaque bodies, that have no light of their own, but shine by the reflected light of the sun, which is a great body of fire, and is the source of light and heat to all other bodies in the solar system.

Tyro. Are the planets inhabited?

Philo. They probably are; for it is not to be supposed that the Almighty created so many worlds for no other purpose, than merely to afford a faint glimmering light to the inhabitants of this earth, especially as we might have enjoyed a much greater light at a far less expence, namely, by the addition of another moon.

Tyro. What do you mean by the comets?

Philo. The comets are certain dark or opaque bodies, like the planets, and move round the sun, but in very eccentric orbits, being sometimes so far from him, that their cold must be excessive, and sometimes so near him, that their heat must be so intense, as would prove altogether intolerable to an inhabitant of this earth; and would even destroy, or at least vitrify, the earth itself. Sir Isaac Newton computed the heat of the comet which appeared

in 1680, when nearest the sun, to be 2000 times greater than that of red-hot iron; and that being thus heated, it must retain its heat until it comes round again, although its period should be more than 20,000 years; and it is computed to be only 575.. The theory of comets is not as yet very distinctly ascertained. There are supposed to be 21 comets belonging to the solar system; but the periods or returns of three of them only are known with any tolerable certainty. One of them was expected to return in 1789, but has not yet appeared. Comets are always attended with long transparent trains or tails, issuing from that side of them which is turned away from the sun. Comets were formerly supposed to be prodigies or portents, and to foretel some great event or revolution, such as the fall of empires, or the death of some eminent and distinguished personage; but they are now known to have no more connection with the civil or political affairs of this world, than any other of the heavenly bodies.

Tyro. What do you mean by the fixed stars?

Philo. All the other heavenly bodies, except the sun, planets, and comets. They are called fixed stars, because they always keep the same place, or relative distance from one another. Their number is probably infinite; but those discoverable by the naked eye, do not exceed 1000; and those discoverable by glasses, do not amount to above 2000; in all 3000. Their appearing so numerous, or rather numberless, to the naked eye, is owing to our looking upon them

them in a confused manner, and without reducing them to order. They are supposed to be suns, each of them as large as ours, and to have planets, both primary and secondary, revolving round them. What a grand and exalted idea does this give us of the works of creation, and of the power, wisdom, and goodness of the adorable Creator!

S U P P L E M E N T.

S E C T. I.

*Concerning the true Figure and Magnitude of the
EARTH, with the Proportion of LAND and
WATER on its Surface.*

THOUGH the earth be round, as we hope we have clearly demonstrated in the beginning of this work (p. 2, 3, &c.) yet it is not an exact globe or sphere, but only a spheroid; that is, a figure somewhat approaching to, or resembling a sphere, being flatted (like an orange) towards the poles, and swelling out towards the equator. This protuberance of the equatorial parts, and shrinking in of the polar regions, is owing to the centrifugal force arising from the earth's turning round its own axis in the space of 24 hours: it is the same force, which a stone in a sling is known to acquire by being swiftly whirled round in a circular manner, and by which it has a strong tendency to recede or fly from the hand, or centre of motion. In like manner all the parts of the earth endeavour to fly off from the axis of motion, and would actually do so if they were not kept together by a far superior force, viz. that of gravity, by which they constantly tend towards the earth's centre: this last, therefore,

fore, is called the centripetal force, and acts in direct opposition to the centrifugal.

When a strong and a weak force act in opposition to each other, the effect of the former will be diminished by the latter; and as the centrifugal force is greatest in the parts about the equator, where the distance from the axis is greatest of all, so the force of gravity will be there most diminished by it, and consequently all those parts must have receded farther from the centre when the earth was first put in motion; and as all the parts of the earth are connected by a mutual cohesion, it follows, that in proportion as the equatorial parts receded, the Polar parts must have acceded or approached nearer to the centre, and therefore must have become flatter than the other parts; that is, the earth must have assumed the figure, not of a globe or sphere, but, as we have already observed, of a spheroid. It appears from the principles of physics, that the force of gravity, or the centripetal force, is to the centrifugal as 289 to 1 under the equator; and the latter gradually decreases as you retire from the equator towards the poles, at which two last places it ceases to act entirely; for there, as there is no rotatory motion of the earth, there is consequently no centrifugal force, and in these two points therefore gravity exerts its full effect.

Now, since gravity gradually encreases from the equator to the poles, it will have a sensible influence upon the motion of long pendulums

by encreasing or diminishing their weight, in proportion as they are carried nearer to the poles or the equator; for, according as their weight is greater, they vibrate the quicker, and *vice versa*: therefore a pendulum, which vibrates seconds at London, will not do the same at the equator, where gravity is less, and consequently the pendulum lighter; for there it will vibrate slower, and the clock will by that means lose time. The truth is, it was the irregular going of a pendulum clock which first suggested the idea of the different force of gravity in different latitudes; for in 1672, Mr. Richer carried a clock from Paris to Cayenne, in north lat. $4^{\circ} 56' 17''$, where he found, that, in order to its beating seconds of mean time, it was necessary to shorten the pendulum one line and a quarter, or a little more than one tenth of an inch; which plainly proved, that gravity was less there than at Paris or London.

The spheroidical figure of the earth being once ascertained, the next point to be determined was how much it differed from a real sphere; and this, it was thought, might most effectually be done by measuring a degree of the meridian: for it was well known, that, if the figure was not spherical, the degrees could not be equal in different latitudes, but must be less near the equator, where the earth was rounder, and greater towards the poles, where it was flatter.

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This task, therefore, of measuring a degree of the meridian, was first undertaken by the famous Cassini, who in 1718 measured the length of the meridian through France, and found that a degree in the parallel of $49^{\circ} 22'$ was equal to 57,183 toises. In 1735, by the joint order of the Kings of France and Spain, a degree was measured at Quito, in Peru, in latitude $1^{\circ} 10'$, and was found there equal to 56,767 $\frac{4}{5}$ toises. In 1736, by the French King's order, a degree was measured at the Arctic circle, and found to contain 57,438 toises. 824 toises are equal to an English mile.

From these several measures of a degree in the different parts of the meridian, it is found by calculation, that the axis of the Earth is to a diameter of the equator as 1019 to 1024. And it is from thence also found, that the axis of the earth is 7932 miles, and a diameter of the equator 7971, which therefore exceeds the axis by 39 miles. By the same calculation it is likewise found, that a degree at the pole exceeds a degree at the equator by 830 toises, or a little more than an English mile; and that a degree of the meridian in the parallel of $54^{\circ} 44'$ is equal to a degree on the equator, which exceeds the first degree of the meridian by 546 toises. If we add the toises in the two extreme degrees of the meridian together, half the sum will be 57,041, which is the length of a mean degree, or degree in the meridian of a globe just equal in bulk to our spheroidical earth. Then divide 57,041 by 824, and the

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quotient $69\frac{1}{8}\frac{8}{2}\frac{5}{4}$ will be the length of a degree in a great circle of such a globe; which multiplied by 360, will give 24,922 miles for the circumference of a globe equal to the earth; whose diameter therefore will be 7933 English miles. The diameter of the earth being known, the square miles contained in its surface will be 197,706,226; and its solid contents in cubic miles will be upwards of 26,139,500,000, or near 26,140 millions.

As to the proportion, which the land bears to the water on the surface of the earth, it is perhaps impossible to determine it exactly. Some probable conjecture, however, may be formed with regard to it by the following experiment: Suppose, of the papers that cover the artificial globe, you cut out carefully, with a pair of scissars, those parts that represent land, and weigh them in a nice balance. Then do the same with those parts that represent water; and the weight of the two parcels of papers compared together will give you the proportion of the land to the water.

This I have seen done with the papers that cover the surface of Mr. Senex's 28 inch globe, and the result was as follows: The papers representing land weighed 367 grains, and those representing water 1125 grains. The weight therefore of the whole was 1492 grains, a fourth part of which is 373 grains, which is more than the weight of the land 367, though very near it. The proportion therefore of land to water is as 1 to 3, or the land is $\frac{1}{4}$ of the earth's surface very nearly.

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S E C T. II.

Of the ATMOSPHERE.

THE air is that thin, invifible fluid, which furrounds the earth to a confiderable height; accompanies it in its diurnal motion round its own axis, and in its annual motion round the fun: in fhort, it is that in which we live and breathe, and, together with the clouds and vapours, that float in it, is called the atmofphere. The air is juftly reckoned among the number of fluids, becaufe it has all the properties by which a fluid is diftinguifhed. It yields to the fmalleft force impreffed on it; its parts are eafily moved among themfelves; it preffes according to its perpendicular height; and its preffure is every way equal.

That the air is a fluid, confifting of fuch particles as have no cohesion betwixt them, but eafily glide over one another, and yield to the flighteft impreffion, appears from that eafe and freedom with which animals breathe in it, and move through it without any difficulty or fenfible refiftance. But it differs from all other fluids in the four following particulars: 1. It can be compressed into a much lefs fpace than that which it naturally occupies, which no other fluid can, at leaft not to any confiderable degree.* 2. It cannot be congealed or fixed, as other fluids may. 3. It is of a different density in every part upward from the

* It has been found by late experiments, that water may be compressed, though not very much.

earth's surface, decreasing in its weight, bulk for bulk, the higher it rises; and therefore must also decrease in density. 4. It is of an elastic or springy nature, and the force of its spring is equal to its weight.

That air is a body, is evident from its excluding all other bodies out of the space it possesses; for if a glass jar be plunged with its mouth downward into a vessel of water, there will but very little water get into the jar, because the air, of which it is full, keeps the water out. As air is a body, it must needs have gravity or weight; and that it is weighty may be thus proved. Let the air be taken out of a vessel by means of the air pump; then, having weighed the vessel, let the air in again; and upon weighing it when re-filled with air, it will be found considerably heavier. Thus a bottle, that holds a wine quart, being emptied of air and weighed, is found to be about 16 grains lighter than when the air is let into it again; which shews, that a quart of air weighs 16 grains. But a quart of water weighs 14,621 grains; this divided by 16, quotes 914 in round numbers; which shews that water is 914 times as heavy as air near the surface of the earth.

As the air rises above the earth's surface, it grows thinner or rarer, and consequently lighter, bulk for bulk. For as it is of an elastic or springy nature, the upper parts, being less pressed than the lower, will for that reason expand themselves, and occupy a larger space.

Dr.

Dr. Cotes has proved, that if altitudes in the air be taken in arithmetical proportion, the rarity of the air will be in geometrical proportion. Thus, at the height of 7 miles, the air is 4 times thinner and lighter than at the surface of the earth; at the height of 14 miles, it is sixteen times thinner and lighter; at 21 miles, it is 64 times; at 28 miles, it is 256 times; at 35 miles, it is 1024; and so on continually, the latter numbers encreasing in geometrical, as the former do in arithmetical proportion. And hence it is easy to prove, that a cubic inch of such air as we breathe, would be so much rarefied at the altitude of 500 miles, that it would fill a hollow sphere equal in diameter to the orbit of Saturn.

But the real weight or pressure of the air is most exactly determined by what is commonly called the Torricellian experiment, which is performed in this manner: Take a glass tube about three feet long, and open at one end; fill it with quicksilver, and putting your finger upon the open end, turn that end downward, and immerse it into a small vessel of quicksilver, without letting in any air: then take away your finger; and the quicksilver will remain suspended in the tube $29\frac{1}{2}$ inches above the surface in the vessel; sometimes more, and at other times less, as the weight of the air is varied by winds and other causes.

That the quicksilver in the tube is kept up by the pressure of the atmosphere upon that in the basin, is evident from this, that if the
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bason and tube be put under a glass, and the air be then taken out of the glass, all the quicksilver in the tube will fall down into the bason; and if the air be let in again, the quicksilver will rise to the same height as before. Therefore the air's pressure on the surface of the earth is equal to the weight of $29\frac{1}{2}$ inches of quicksilver all over the earth's surface at a mean rate. A square column of quicksilver, $29\frac{1}{2}$ inches high, and one inch thick, weighs just 15 pounds, which is equal to the pressure of air upon every square inch of the earth's surface; and 144 times as much, or 2160 pounds, upon every square foot; because a square foot contains 144 square inches. At this rate, a middle-sized man, whose surface may be about 14 square feet, sustains a pressure of 30,240 pounds, when the air is of a mean gravity; a pressure, which would be insupportable, and even fatal to us, were it not equal on every part, and counterbalanced by the spring of the air within us, which is diffused through the whole body, and re-acts with an equal force against the outward pressure.

Now, since the earth's surface contains (in round numbers) 200,000,000 square miles, and every square mile 27,878,400 square feet, there must be 5,575,680,000,000,000 square feet on the earth's surface; which multiplied by 2160 pounds (the pressure on each square foot) gives 12,043,468,800,000,000,000 pounds for the pressure or weight of the whole atmosphere.

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The same cause, that makes Mercury ascend in a tube to the height of $29\frac{1}{2}$ inches, is the occasion of water ascending in a pump to the height of 33 feet; for it will ascend no higher: so that a column of water 33 feet high, is equal in weight to a column of quicksilver of the same diameter, $29\frac{1}{2}$ inches high; and to as thick a column of air, reaching from the earth's surface to the top of the atmosphere.

The instrument, with which the Torricellian experiment is performed, being now generally used to determine the changes in the weight of the air, and consequently the changes of the weather, is for that reason called the barometer, or weather-glass. Sometimes the air is so heavy and elastic, as to support the mercury in the tube at the height of 31 inches; at other times it is so light and unelastic, as to suffer it to fall below 28 inches. The difference between these is three inches, that is, about $\frac{1}{9}$ th of the whole weight of the atmosphere. Our bodies, therefore, are sometimes pressed with a weight one ninth more, or one ninth less than they are at other times, that is, with about 3360 pounds more weight at one time than another. This must no doubt have a considerable effect upon our feelings, and consequently upon our health; and the fact is, that it has so: but we are apt to ascribe this effect to a wrong cause. When we feel ourselves dull and languid, we think it is owing to the air's being too thick and heavy about us. But it is just the reverse. The air is then too light and

and thin, as is evident from its wanting strength to bear up the vapours that compose the clouds, and from the mercury's sinking in the barometer. On the contrary, when the air is thick and heavy, the clouds mount high, the air becomes more strong and elastic, by which means it balances the spring of air within us, braces up our blood-vessels and nerves, and makes us brisk and lively.

It is impossible, in a short sketch of this kind, to explain all the uses and properties of the air: I shall therefore content myself with mentioning a few more of the most remarkable. According to Dr. Keill, and other astronomical writers, it is entirely owing to the atmosphere that the heavens appear bright in the day-time. For, without the atmosphere, only that part of the heavens would shine in which the sun was placed; and if we could live without air, and should turn our backs towards the sun, the whole heavens would appear as dark as in the night, and the stars would be seen as clear as in the nocturnal sky. In this case we should have no twilight; but a sudden transition from the brightest sunshine to the blackest darkness immediately after sun-set; and from the blackest darkness to the brightest sunshine at sun-rising; which would be extremely inconvenient, if not blinding, to all mortals. But, by means of the atmosphere, we enjoy the sun's light, reflected from the ærial particles, for some time before he rises, and after he sets. For, when the sun has descended below the horizon,

horizon, and consequently is concealed from our sight, the atmosphere, being higher than we, has his light still imparted to it, and reflects it to us. This light, or rather twilight, gradually decreases, till the sun has got 18 degrees below the horizon; and then all that part of the atmosphere which is above us is dark. From the length of the twilight the Doctor has calculated the height of the atmosphere (so far as it is dense enough to reflect any light) to be about 44 miles. But it is seldom dense enough at two miles height to bear up the clouds. The real height, however, of the atmosphere cannot well be ascertained: It grows gradually rarer and rarer, the higher it ascends; and as it is impossible to set any bounds to its rarefaction, it seems equally impossible to fix any limits to its height.

The air is rarefied, or made to swell with heat; and of this property wind is the necessary consequence. For when any part of the air is heated by the sun, or otherwise, it will swell, and thereby affect the adjacent air; and so, by various degrees of heat in different places, there will arise various winds. When the air is much heated, it will ascend towards the upper part of the atmosphere, and the adjacent air will rush in to supply its place; and therefore there will be a stream or current of air from all parts towards the place where the heat is. And hence we see the reason why the air rushes with such force into a glass-house, or tile-kiln, or towards any place where a great
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fire is made; and also why smoke is carried up a chimney, and why the air rushes in at the key-hole of the door, or any small chink, when there is a fire in the room. So, in general, we may conclude, that the air will press towards that part of the world where it is most heated. Upon this principle we can easily account for the trade winds, which constantly blow from east to west between the tropics, and chiefly about the equator. For as the sun moves from east to west, and as the air immediately under the sun must be more strongly heated than that upon any other part of the earth's surface, it will naturally ascend into the higher regions, and the adjacent air will as naturally rush in to supply its place; and thus a constant stream or current of air, that is of wind, will follow the sun in his daily course from east to west; only, on the north-side of the equator, it will incline a little to the north; and on the south side, to the south.

This general course of the wind about the equator is changed in several places, and by a variety of causes. 1. By exhalations. 2. By the falling of great quantities of rain, which condense the air. 3. By burning sands, which rarefy it. 4. By chains of high mountains, which break its current, and alter its direction. And 5. By the declination of the sun towards the north side of the equator in summer, and towards the south side of it in winter. To these, and other causes of a similar nature, are owing, 1. The irregularity and uncertainty

certainly of the winds in climates at a considerable distance from the equator, as in most parts of Europe. 2. Those periodical winds, called monsoons, which in the Indian seas blow half a year one way, and the other half another. 3. Those winds, which, on the coast of Guinea, in Africa, and on that part of Peru in South America, blow almost always from the west. 4. The sea and land breezes, which, in hot countries, blow generally from the sea in the day-time, and from the land in the night, but which do not extend above two or three leagues from the shore. And 5. All those storms, hurricanes, whirlwinds, and irregularities which happen at different times and places.

All common air is impregnated with a certain vivifying spirit or quality, which is necessary to continue the lives of animals; and this, in a gallon of air, is sufficient for one man during the space of a minute, and not much longer. This spirit in air is destroyed by passing through the lungs of animals; and hence it is that an animal dies soon, after being put under a vessel which admits no fresh air to come to it.

This spirit is also in the air which is in water, but requires a constant supply from the atmosphere above; for fish die when they are excluded from fresh air, as in a pond that is closely frozen over. And the little eggs of insects, if stopped up in a glass, will not produce their young, though assisted by a kindly warmth; neither will the seeds of plants grow, though
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mixed with good earth, if they are inclosed in a glass. This enlivening quality in air is also destroyed by the air's passing through fire, particularly charcoal fire, or the flame of sulphur; and hence it is, that smoky chimnies must be very unwholesome, especially if the rooms they are in be small and close. Air is also corrupted by remaining closely pent up in any place for a considerable time; as in the holds of ships, in oil-cisterns or wine-cellars, and in deep pits or wells that have been long disused and covered over. In all these the air is sometimes so much vitiated, as to prove instant death to any animal that comes into it. The corruption of this vivifying spirit in air seems to be the real cause of epidemical diseases, and still more of pestilential and contagious disorders.

It is well known, that the atmosphere is the common receptacle of all the exhalations and vapours that arise from different bodies; of the steam and smoke of things burnt or melted; the fogs or vapours proceeding from damp watery places; and of the effluvia from sulphureous, nitrous, acid, and alkaline bodies. In a word, whatever may be called volatile, rises in the air to greater or less heights according to its specific gravity. When the effluvia, which arise from acid and alkaline bodies, meet each other in the air, there will be a strong conflict or fermentation between them; which will sometimes be so great as to produce a fire; and if the effluvia be combustible, the fire will
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run from one part to another, just as the inflammable matter happens to lie.

That this will be the consequence of two such substances coming in contact may be easily proved by mixing an acid and an alkaline fluid together, as the spirit of nitre and the oil of cloves; upon the doing of which a sudden ferment, with a fine flame, will arise; and if the ingredients be very pure and strong, there will be a sudden explosion.

Whoever considers the nature of fermentation, will be at no loss to account for the dreadful effects of thunder and lightning; for the effluvia of sulphureous and nitrous bodies, and others that rise into the atmosphere, will ferment with each other, and take fire, sometimes by the assistance of the sun's heat, and very often of themselves. If the inflammable matter be thin and light, it will mount up into the higher regions of the air, where it will flash without making any noise, or doing any harm; but if it be thick and heavy, it will lie near the surface of the earth, where taking fire, it will explode with a surprising force; and by its heat rarefy and drive away the air, kill men and cattle, split trees, walls, rocks, &c. and be accompanied with a terrible noise, or loud claps of thunder. The heat of lightning appears to be of a quite different nature from that of other fires; for it has been known to melt a sword without hurting the scabbard in which it was sheathed; and money in a man's pocket, without hurting the pocket itself;

self; the reason of which seems to be, that, by its great subtilty, it easily passes through loose or soft bodies, and spends its force chiefly upon the hard ones.

Much of the same kind with lightning are those explosions, called fulminating, or fire-damps, which sometimes happen in mines; and are occasioned by sulphureous and nitrous, or rather oleaginous particles, rising from the mine, and mixing with the air, where they will be set on fire by the lights which the workmen are obliged to make use of. Such air may be artificially produced in the following manner: Exhaust the receiver of an air-pump, and let the air into it through the flame of the oil of turpentine; then if you remove the cover of the receiver, and hold a candle to that air, it will take fire, and burn more or less intensely, according to the density of the oleaginous matter.

When such combustible matter, as we have now mentioned, kindles in the bowels of the earth, where there is little or no vent, it produces earthquakes, and violent storms and hurricanes of wind, when it breaks forth into the air. An artificial earthquake may be made thus: Take 20 or even 10 pounds of iron filings, and as many of sulphur; mix, work and temper the whole with a little water, so as to form a mass of the consistence of a firm paste. This, being buried three or four feet under ground, will, in 6 or 7 hours time, have a prodigious effect: the earth will begin to trem-
ble,

ble, crack and smoke, and fire and flame will burst out. From this experiment we may form a very probable conjecture as to the cause of the eruptions of Mount *Ætna*, *Vesuvius*, and other volcanos, these being, in all likelihood, set on fire at first by the mixture of metalline and sulphureous particles.

N. B. Thunder and lightning, and even earthquakes, have of late been attempted to be solved upon very different principles, viz. those of electricity. It is probable, indeed, that the electric matter, which pervades all nature, and particularly the atmosphere and the body of the earth, has a considerable share in producing, though it be not the sole cause of, these terrible phænomena.

S E C T. III.

Of the T I D E S.

A Tide is that motion of the water in the seas and rivers, by which it is found regularly to rise and fall. The general cause of this motion of the water seems to have been first discovered by Kepler, who, in his *Introduction to the Physics of the Heavens*, expresses himself thus: "The orb of the attracting power of the moon extends as far as the earth, and draws the waters under the torrid zone, acting upon those places where it is vertical; insensibly,

bly, indeed, on confined seas and bays, but sensibly on the ocean, whose beds are large, and whose waters have the liberty of reciprocation, that is, of rising and falling." And, in his *Lunar Astronomy*, he says, "That the cause of the tides of the sea appears to be the bodies of the sun and moon drawing the waters of the sea." This hint being given, the immortal Sir Isaac Newton improved it, and wrote so fully and satisfactorily on the subject, as to make it in a great measure his own, particularly by explaining the reason why the waters rise on that side of the earth which is farthest from the moon, as well as on that which is nearest to her. The substance of what he says on this curious topic is as follows.

The two great powers, that actuate all matter, are gravity and attraction. By the former, all bodies tend towards the centre of the earth; and the case is no doubt the same in all other spheres or globes. By the latter, the sun, the moon and the earth, and probably too the other planets, mutually draw or attract each other; but with forces, however, which gradually decrease as the distances of the attracting bodies decrease, and that too in proportion to the square of those distances; in other words, at double the distance the power of attraction is four times less, at triple the distance it is nine times less, at quadruple the distance it is sixteen times less, at five times the distance it is twenty-five times less, &c.

Now,

Now, as the earth is attracted by the sun and moon, therefore all the parts of the earth will not gravitate towards its centre in the same manner as if those parts were not affected by such attractions. And it is evident, that, were the earth entirely free from such actions of the sun and moon, the ocean tending equally, on all sides, towards its centre by the force of gravity, would maintain a perfectly spherical figure. But as the case is otherwise, the water of the ocean must needs rise higher in those places where the sun and moon diminish its gravity, or where the sun and moon have the greatest attraction.

The moon, however, being by much the nearest of these two luminaries, will operate with the greatest force in producing this rise of the waters, or the ebbing and flowing of the sea; and its influence in this respect must be as follows: First upon the hemisphere towards the moon; where the middle point being nearest the moon, and therefore most attracted by her (directly contrary to its natural gravity, or tendency to the centre) is less pressed by gravitation than any other part of the surface of that hemisphere, and consequently the waters will there be the highest. Secondly, upon the hemisphere that is farthest from the moon; where the middle point being least attracted by the moon (by reason of its being at the greatest distance from her) is left behind, while all the other parts, and even the centre itself, are more attracted towards her; from whence it

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will follow, that the surface of the water at the middle of that hemisphere will be higher, or more remote from the centre, than any other part of it.

On the other hand, those parts of the earth, where the moon appears in the horizon, or is 90 degrees distant from the Zenith and Nadir, will have the ebbs or lowest waters. For, as the waters in the Zenith and Nadir rise at the same time, the waters in the neighbourhood will rush in towards them, in order to maintain the equilibrium; and to supply the place of these last, others will move the same way, and so on gradually, till the motion reaches to 90 degrees distance, from the said Zenith and Nadir; consequently in those places where the moon appears in the horizon, or which are 90 degrees distant from the Zenith and Nadir, the waters will be the lowest.

That part of the globe, therefore, which is nearest to the moon, and that which is farthest from her, will naturally be the highest in their respective hemispheres; the former being really more elevated, and the latter less depressed, by the moon's attraction, than the adjacent parts: so that these two points may now be conceived as the summits of two opposite mountains of water, or the whole globe may be supposed to be thrown into a spheroidical or oval figure, whose longest diameter, if produced, would pass through the moon, and its shortest be where she is in the horizon, or at 90 degrees distance. And as the moon seems to move

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round the earth from east to west, the longer diameter of the spheroid, following her motion, will occasion the two tides of flood and the two tides of ebb that happen in about 25 hours; for that is the time nearly, which the moon takes up in moving from the meridian of any place to the same meridian again.*

When the sun and moon are in conjunction, or opposition, that is, at new or full moon, the attraction of both these bodies acting upon the earth in the same direction, or in the same right line, their force is united to elevate the waters; and consequently then there will be spring-tides. When the moon is in her quadratures, her attraction acts in one direction, and the sun's in a quite contrary; by which means they oppose or counteract one another, the moon raising the waters where the sun depresses them, and *vice versa*; the consequence of which is, that then there will be neap-tides.

Though the force by which the tides are raised, is continually encreasing from the time of the moon's quadrature to her conjunction or opposition, after which it gradually decreases till the next quadrature; yet the highest spring-tide is not just at the new or full moon, but a day or two after; which may be easily accounted for thus: conceive every tide as raised

* *Note.* The reason why the moon takes up about 25 hours in moving from any one meridian to the same meridian again, is, that though in her daily course she seems to move round the earth from east to west, yet she really moves round it from west to east in the space of a month.

by a double force, viz. some part of the force that raised the last tide still remaining, and the force of a new impulse. When both these together amount to more than the whole force which raised the last tide, the present tide must rise higher than the preceding one did. Suppose the remaining force to be always half the whole force of the last tide; suppose the new impulse, just at new or full moon, to be 18, and the whole force, with which that tide is raised, to be 28. Let the new impulse of the new tide be but 17; then $17 + 14$ (that is, half of 28) = 31: this tide will therefore rise higher than the last. Let the new impulse of the next tide be but 16; then $16 + 15\frac{1}{2}$ (that is, half of 31) = $31\frac{1}{2}$: consequently this tide will rise still higher than the last did, though the force of the attraction of the two luminaries, by which the tides are raised, is now considerably diminished. For the same reason the deadeft neap-tides will fall out, not precisely at the moon's quarters, but some time after.

If the two opposite protuberances or summits of the two mountains of water, we have mentioned above, were always exactly at the poles of the earth, there would be no rising and falling of the waters by means of the earth's rotation round its axis, or no tides at all, because at the poles the earth has no rotatory motion round its axis; and in this case it would constantly be high water at the poles, and low water at the Equator. On the other hand, when these two summits are farthest from the

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the poles, that is, upon the Equator, the rise and fall of the waters, by means of the earth's rotation, will be the greatest; for the two summits then describing a great circle of the globe in the same time they used to describe a lesser circle parallel to the Equator, will consequently move with greater rapidity, and being dashed against the shores with greater force, will for that reason rise the higher.

In general, therefore, it may be laid down as a maxim that the nearer any place is to the Equator, the rise and fall of the waters will be the greater; and the nearer it is to the poles, the rise and fall will be the less. And as the rise of the water is owing to the joint influence of the sun and moon, it naturally follows, that when these two luminaries are in conjunction or opposition, in or near the equinoctial, as in March and September, the spring-tides must rise higher, (the summits of the two mountains being then upon the Equator) than when they are in conjunction or opposition in the tropics, as in June and December; and, for the very same reason, the neap-tides are weaker in the two former months than they are in the latter. Yet, though the highest tides happen at the equinoxes, they do not fall exactly on the equinoctial days, but some time before the vernal, and some time after the autumnal equinox, viz. in February and October; the reason of which is, that the sun being nearer the earth in the winter months than he is in the summer ones,

his attractive power must consequently be stronger in the former than it is in the latter.

It is equally certain from what has been said, that the greater the moon's meridian altitude is in any place, the greater will be those tides which happen when she is above the horizon; and the greater her meridian depression is, the greater will be those tides which happen when she is below the horizon. Moreover, the summer day, and the winter night tides have a tendency to be the highest, because the sun's summer altitude, and his winter depression, are the greatest; but this is more particularly the case when the moon has north declination in summer, and south declination in winter.

All the phenomena, hitherto explained, would exactly take place, were the whole surface of the earth covered with water. But as it is not, and as the natural course of the tides from east to west is interrupted by large continents, and by an infinite number of islands, there consequently must arise, in many places near the land, a great variety of other appearances beside those I have mentioned. These appearances, therefore, will require a particular solution; and in this we must attend to the situation of shores, straits, shoals, winds, and many other things which help to produce them.

For instance; as the sea has no visible passage between Europe and Africa, let them be supposed to be one continent, extending from 72 degrees north to 34 degrees south latitude: the middle between these two would be in latitude

titude 19 degrees north, near Cape Blanco on the west coast of Africa. But it is impossible that the tide should flow to the westward upon the western coast of Africa, because the continent for above 50 degrees, both northward and southward, bounds the Atlantic ocean on the east, and prevents the direct passage of the tide either from the Indian or the Pacific ocean into it: therefore, if any regular tide, occasioned by the motion of the sea, from east to west, should reach Cape Blanco, it must come either from the north of Europe southward, or from the south of Africa northward, to the said latitude upon the west coast of Africa. And this theory is perfectly agreeable to fact and experience; for it is well known, that the tide flows southward along the west coast of Norway, from the north cape to the Naze, or entrance of the Baltic sea, and so proceeds to the southward along the east coast of Great Britain, and in its passage supplies all the harbours in those parts with the tide one after another, the coast of Scotland having the tide first, as lying farthest to the northward. Thus, on the days of the full, or change, it is high water at Aberdeen 45 minutes after 12; but at Tinmouth Bar, the same day, not till three o'clock. From thence, rolling to the southward, it makes high water at the Spurn a little after 5; but not till 6 at Hull, by reason of the time required for its passage up the river; from thence passing over the Wellbank into Yarmouth-road, it makes high water there a little after 8, but not in the

pier till 9; and it requires near an hour more to make high water at Yarmouth town: in the mean time continuing its course to the southward, it makes high water at Harwich at half past 10, at the Nore at 12, at Gravesend at half past 1, and at London at 3 o'clock. Thus it appears, that the same tide, which produces high water at Tinmouth Bar at 3 o'clock in the morning, does not produce high water at London till 3 in the afternoon.

While the tide, or high water, is thus gliding to the southward along the east coast of England, it also flows to the southward along the west coasts of Scotland and Ireland, and a branch of it falls into St. George's Channel, the flood running up north-east, as may be naturally inferred from its being high water at Waterford above three hours before it is high water at Dublin, or thereabouts, on that coast; and it is three quarters of an hour ebb at Dublin before it is high water at the Isle of Man.

But, not to draw out this article to too great a length, I shall content myself with observing, that the tide flows to the southward from the coast of Ireland, and in its passage a branch of it falls into the English Channel between the Lizard and Ushant; this progress of the tide to the southward may easily be proved by its being high water on the day of the full and changes at Cape Clear a little after 4 o'clock, and at Ushant about 6, and at the Lizard after 7. The Lizard and Ushant may properly be called

called the chaps of the English Channel, between which the tide flows to the eastward along the coasts of England and France, till it comes to the Goodwin or Galloper, where it meets the tide above mentioned, which flows to the southward along the eastern coast of England; and the meeting of these two tides contributes very much towards sending a powerful tide up the river Thames to London. And when the natural course of these two tides has been interrupted by a sudden change of the wind, by which means that tide was accelerated which had before been retarded, and that driven back which was before hurried in by the wind, it has been known to occasion high water twice in 3 or 4 hours, which by those who did not understand this natural cause, has been looked upon as a prodigy.

If it should be said, that this course of the tides east, or east-north-east, up the channel, is inconsistent with the theory which supposes them to move from east to west, the answer is obvious. Though in the main ocean, where the tides meet with no obstruction, they regularly follow the influence of the sun and moon in moving from east to west, yet in rivers, channels, and even in narrow seas, they sometimes move towards the north, the south, or even towards the east, according as the waters in the neighbourhood are higher or lower.

This will be easily understood by any one, who is sufficiently acquainted with hydrostaticks

to know, that water, if not counteracted by some superior power, always endeavours to come to a level.

There are no tides in lakes, because they are generally so small, that when the moon is vertical she attracts every part of them alike, and as all the water is thus rendered equally light, no part of it can rise higher than another. To the same cause it is supposed to be owing, that the Mediterranean and Baltic seas have no tides, at least no very perceptible ones; though a different reason is sometimes assigned for this phenomenon, and that is, that the inlets, by which these seas communicate with the ocean, are so small, as not to be capable, in the space of a few hours, to receive or discharge a sufficient quantity of water to raise or sink their surfaces considerably. The time of high water, in any place, happens about the same hour after a period of 15 days nearly, which is the interval between one spring-tide and another; and during that period the time of high water happens every day later by about 48 minutes.

We shall conclude this account of the tides with a few words concerning the saltness and depth of the sea. Dr. Halley has assigned the most probable cause of its saltness. He says, that all the lakes in the world, properly so called, are found to be salt; some more, some less than the ocean, which in the present case may also be considered as a lake; since by that
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term is meant nothing more than such standing waters as perpetually receive rivers running into them, and have no exit or evacuation, but what is exhaled by heat. And having given us a list of the most remarkable lakes, he supposes, that as all those lakes receive rivers, and none of them have any discharge but by exhalation, so it will be necessary, that their waters rise till such time as their surfaces are sufficiently extended to make them exhale in vapour as much water as is poured in by the rivers. But the vapours thus exhaled are perfectly fresh; so that the saline particles, that are brought in by the rivers, remain behind, while the fresh ones only evaporate; and hence it is evident, that the salt in the lakes will be continually augmented, and the water grow saltier and saltier. But in lakes where the water runs off as fast as the fresh water rivers pour in, the saline particles can never be accumulated to any considerable degree. Now if this be the true cause of the saltness of lakes, it is not improbable that it may likewise be the reason of the saltness of the sea.

That exhalations from sea water are perfectly fresh, is proved by a variety of experiments; consequently all rain, hail, and snow is fresh, and so must the rivers be that originate from or are supplied by them. Rain water, just fallen, is supposed to be the purest and lightest of all waters with regard to earthy particles; and as it is reckoned to be of the same kind wherever

it falls, philosophers have chosen it to be the measure, with which the weight of all other bodies is best compared. After all, there is no water perfectly pure; for even this rain water abounds with the eggs of many very small animals, which, floating in the atmosphere, are brought by the rain to the earth. The water of springs and rivers is generally impregnated with the particles of earths, salts, sulphurs, minerals, &c. which the water is strained through, or runs over; and is, for that reason, somewhat heavier than rain water, though not so heavy as sea water, on account of the quantity of salt with which the latter is impregnated.

The depth of water in the sea is various. In many places its bottom may be found by a piece of lead tied to the end of a long line, and even the nature of its bottom ascertained by filling the lower end of the lead with tallow, by which means it will bring up, sticking to it, some of the loose particles from the bottom of the sea, and thereby shew the nature of that bottom, whether it be sand, gravel, shells, mud, &c. And though in many places no bottom can be found by sounding, or letting down the lead, it must not thence be inferred that the sea has no bottom. It has been conjectured, with great probability, that the depths of the sea, and the heights of the land above the surface of the sea, are not very different. Now it is well known, that there is no land,

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or summit of a mountain, more than three or four miles in perpendicular height above the level of the sea; therefore it may be supposed, that the sea is not much more than three or four miles deep in any part; and could an exact representation be given of the depths of the sea in different places, it would probably appear, that it has much the same irregularity in its bottom, as the land has in its surface.

SECT.

S E C T. IV.

A SHORT SYSTEM of CHRONOLOGY.

CHRONOLOGY, or the doctrine of time, is intimately connected with the use of the globes, inasmuch as many of the problems require a person to be thoroughly acquainted with the nature of years, months, and days; and also as both the Julian and Gregorian calendars, or (as they are commonly called) the Old and New Stile, are inscribed upon the Horizons of many globes, and therefore ought to be explained in all books that treat of their use.

Time is divided into days, hours, weeks, months, and years. Days are either natural or artificial. A natural day is the time that passes while the sun goes from any meridian till he returns to it again; or, to speak more properly, while the earth revolves round its axis. An artificial day is the time between the sun's rising and setting; to which is opposed the night, that is, the time the sun is hid under the Horizon. The natural day is divided into 24 hours, each hour into 60 minutes, each minute into 60 seconds, each second into 60 thirds, &c. The artificial days are always unequal to all the inhabitants that are not under the Equator, except when the sun is in the equinoctial points γ and α , which happens about the 21st of March, and the 22d of September;

tember; at those times the sun rises and sets at fix, to all the inhabitants of the earth.

All nations do not begin their day and reckon their hours alike. In Great Britain, France, and Spain, and in most other countries in Europe, the day is reckoned to begin at midnight, from whence is counted 12 hours till noon, then 12 hours more till next midnight, which makes a natural day. Yet, even in those countries, the astronomers commonly begin their day at noon, and so reckon 24 hours till next noon, and not twice twelve, according to the vulgar computation. The Babylonians began their day at sun-rising, and reckoned 24 hours till he rose again. This way of computation we call the Babylonish hours. In several parts of Germany, they count their hours from sun-setting, calling the first hour after the sun has set, the first hour, &c. till he sets the next day, which they call the 24th hour. These are commonly called the Italian hours. According to both these ways of computation, their hours are either a little greater or less than the $\frac{1}{24}$ part of a natural day, in proportion as the sun rises or sets sooner or later in the succeeding days. They have also this inconvenience, that their mid-day and midnight happen on different hours, according to the seasons of the year. The Jews and Romans formerly divided the artificial days and nights, each into 12 equal parts: these are termed the Jewish hours, and are of different lengths according to the seasons of the

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the year; a Jewish day-hour in summer being longer than one in winter, and night-hour shorter. This method of computing time is now in use among the Turks, and the hours are stiled the first, second, third, &c. hour of the day or night; so that mid-day always falls on the sixth hour of the day.

There is nothing in nature that suggests the idea of dividing time into weeks; so that a week seems to be merely a civil or rather a religious institution, as among all nations, that have any notion of religion, one day in seven is set apart for public worship. For this purpose Christians observe Sunday, or the first day of the week; the Jews observed Saturday, or the seventh day of the week; and the Turks perform their religious ceremonies on Friday.

A month is properly that space of time which is measured by the moon in her course round the earth. A lunar month is either periodical or synodical. A periodical month is the time which the moon takes up in performing her course from one point in the ecliptic till she returns to it again, which is 27 days, 7 hours, 43 minutes, 4'' 45'''; and a synodical month, or (as it is sometimes called) a lunation, is the time betwixt one new moon and the next new moon, which is 29 days, 12 hours, 44' 2'' 53'''. Therefore, though in the space of a year the moon performs 13 revolutions round the earth, or completes 13 periodical months, and 10 days over; yet there are but twelve lunations, or synodical months, and eleven days over, in a year.

year. There is a third kind of month, different from both the former: it is called the civil month, and consists of a certain number of days, either more or fewer, according to the laws and customs of the country where such months are observed.

The completest period of time is a year, in which all the seasons return in succession, and begin anew. A year is either astronomical or civil. An astronomical year again is either fiderial or tropical. The fiderial year is the space of time that passes while the sun goes from any fixed star to the same again. It consists of 365 days, 6 hours, 9' 14". The tropical year is the space of time that passes while the sun goes from either tropic, or from any point of the ecliptic, to the same again. This is somewhat short of the fiderial year, because every point of the ecliptic goes backwards about 50 seconds of a degree in a year, (owing to what is usually called the precession of the equinoxes) thereby meeting the sun, as it were; which makes the sun return to the same point of the ecliptic, about 20 minutes of time before he arrives at the same fixed star from which he set out the preceding year. The tropical year, therefore, is shorter than the fiderial year, and consists of 365 days, 5 hours, 48' 57". The civil year is the same with the political, and is that which is established by the laws of any particular country.

Days, months, and years, however, were all of them originally very imperfect, as resulting
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from very gross observations; and indeed astronomy, in its infant state, afforded no better means of computation. Nay, the year, as instituted by Romulus, the founder of Rome, consisted but of ten months, beginning with the month of March; but as this was short of the sun's period by two months, these were afterwards added by his successor, Numa Pompilius, and were called January and February. By these means the Roman year consisted of 12 months. But the months of this year being lunations, or lunar synodical months, of $29\frac{1}{2}$ days each, this civil lunar year consisted but of 354 days; but as the sun, in revolving once through the ecliptic, was found, in process of time, to take up 365 days, or 11 days more than the lunar year, these were added to it by the emperor Julius Cæsar, and on that account it was called the Julian year. The 11 days added, to render the lunar equal to the solar year, the Greeks called Epagomenæ, and hence their modern name *epacts*.

But the year thus constituted by Julius Cæsar, of 365 days, was observed by the astronomers of that age to be about six hours shorter than the time the sun took up in running through the ecliptic. The emperor, therefore, ordered, that every fourth year should consist of 366 days, in order that the seasons of the year might be always fixed to the same parts of the calendar, and the feasts and fasts be thereby rendered certain and invariable. This he did as Pontifex Maximus, or High Priest in the Roman

Roman hierarchy. This odd day was in every fourth year added to the 24th of February. And, according to the Roman way of reckoning, was the *Dies sextus ante kalendas Martii*, or the sixth day before the first of March; so that there being then *bis sextus dies*, or two sixth days, gave occasion for that year to be called *Annus Biffextilis*, or Biffextile year, which we now commonly call Leap-year.

In order to know whether any particular year be Leap-year or not, divide it by 4, and the remainder, if there be any, shews how many years it is since Leap-year; and, if there be none, then it is Leap-year. Or you may omit the hundreds and thousands, and divide only the units and tens by 4, and the result will be the same. Example: Divide 1792 by 4, the remainder is 0; or divide only 92 by 4, the remainder is likewise 0; consequently 1792 is Leap-year. Divide 1793 by 4, the remainder is 1; or divide only 93 by 4, the remainder is likewise 1; consequently 1793 is the first year after Leap-year.

Six hours, however, were afterwards found to be too much by 11 minutes, 3 seconds, for so much does the solar or tropical year want of 365 days, 6 hours. By the addition, therefore, of six whole hours, the sun each year began his course, or entered the first sign of the ecliptic 11' 3" before the preceding year was ended. This precession of the sun, as it may be called, or, as it is usually termed, of the equinoxes, amounts to one whole day in

131 years. From Julius Cæsar to the Council of *Nice*, A. D. 325, was about 375 years. At that time the vernal equinox fell upon the 21st of March, and consequently every 131 years after, the equinox must anticipate one whole day; therefore the seasons of the year, and festivals of the church, must be rendered moveable, and in time go retrograde through the whole calendar. This soon alarmed the fathers of the primitive church, whose knowledge, or rather whose ignorance, of astronomy never suffered them to suspect any such thing: and as Easter (the principal feast) had been fixed to the Sunday which was the first after the new moon that happened next after the 21st of March, or vernal equinox, they saw with concern the unstable condition of their rubric; and in the time of Pope Gregory XIII. this grievance had grown to so great a height, that the said equinox, and Easter of course, had anticipated the time to which the fathers of the Nicene council supposed they had fixed it, no less than 10 days.

This Pope, therefore, convened a council of the best astronomers of that age, and after a minute examination of the matter, it was ordained, that ten days should be taken from the month of October in 1582, by reckoning the 5th day as the 15th. And to prevent the regress of the equinoxes for the future, and consequently any irregularity in the calendar, it was further ordained, that every hundredth year, which in the Julian account was a Leap-year,

year, should in this be only a common year, and consist but of 365 days; but as that was too much, every four hundredth year was to remain a Leap-year or Bissextile. This reformation of the calendar is called the Gregorian account, or New Stile; and according to this stile was the calendar rectified in England in 1752, by throwing out 11 days in the month of September, as from the Council of Nice to that year 1427 years had elapsed; and, besides, the beginning of the civil year was fixed to the first day of January.

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